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Opus: An Integrated Simulation Model for Transport of Nonpoint-Source Pollutants at the Field Scale

Volume II, User Manual

ABSTRACT

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The Opus model simulates interaction of water movement with the application, transformation, and movement of nonpoint-source pollutants in an agricultural field. The modeled processes include hydrology, erosion, weather, crop growth, agricultural management, nutrient cycling and transport, and pesticide fate. The field size is limited to catchments with a single raingage record and a single soil profile. Time scales vary by process and conditions: from fractions of a second in some hydrologic components to years in annual management cycles. Many processes proceed on a daily time step. This document describes the use of the computer program. Input variables and parameters are described, and relationships among some are explained. Tables and figures assist the user in applying the program to a wide range of possible climates and managements.

KEYWORDS: runoff, erosion,infiltration, simulation, pollution, hydrology, soil water, transport

While supplies last, single copies of this publication may be obtained, at no cost, on request from Dr. R.E. Smith, USDA-ARS, Water Management Research Unit, AERC CSU, Fort Collins, CO 80523.

Copies of this publication may also be purchased from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

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CONTENTS

PREFACE

Documentation of the Opus model is in two volumes: Volume I, Documentation; and Volume II, User Manual. The theoretical and mathematical concepts used are described in volume I. Operation of the computer program is described in volume II.

Opus is designed to be "physically based." Ferreira and Smith (1988) discussed some of the pitfalls of such a claim, which must be kept in mind when applying models. As yet, such complex physical and chemical processes and their interactions cannot be precisely described mathematically, much less simulated by computers. Further imprecision is caused by uncertainties of input and by spatial and temporal variabilities of many assumed "constants." Thus, model results must be carefully analyzed within this context.

Despite its admitted shortcomings and weaknesses, Opus is a relatively powerful tool for assessment and research. Its surface and subsurface hydrology components represent a significant step beyond most currently available models. Compared with other models, Opus' components include a more complete system and represent a generally better balance of relative complexity. Opus has been run thousands of times on climates ranging from very dry to very wet, and on time scales from a single storm to 99 years. Thus many program "bugs" have been discovered and eliminated. As with any computer program, however, it must be assumed that bugs exist; caution is advised.

The Opus program is designed to be used transparently; the original code is neither easily read nor safely modifiable. However, experience with CREAMS and early versions of Opus indicates that some users will wish to read and may attempt to modify the code. Appendixes are therefore provided that include basic code information: a glossary of input and COMMON variables, a list of subprograms and their functions, and a map of COMMON block residence. This information is offered not to encourage code changes but to minimize damage therefrom. Users are discouraged from any modification of Opus code.

OPUS, AN INTEGRATED SIMULATION MODEL FOR TRANSPORT OF NONPOINT-SOURCE POLLUTANTS AT THE FIELD SCALE:
VOLUME II, USER MANUAL

Virginia A. Ferreira and Roger E. Smith

INTRODUCTION

Opus (not an acronym) is a computer simulation model of the water flow and transport system in and on an upland catchment. It is agriculturally focused, and its primary purpose is to estimate the relative effects of different management practices on non-point-source pollution from field-sized areas. Within this capability, the model can also be used for a number of other hydrology related studies. Volume I, which precedes this document, contains the theoretical basis and description of the mathematical models that are integrated in Opus. This volume is designed to assist the user in computer program operation.

Like other comprehensive hydrologic models published for public use, Opus represents a particular balance between current scientific understanding of natural processes and practical constraints, especially the limits of typically available user data. Opus attempts to use modern soil physics in the movement of soil water, and attempts to closely integrate many processes that relate to hydrology and interact with each other. These include plant growth, nutrient cycling, management activities, sediment transport along the surface, and transport of chemicals through the soil.

Opus is limited to small field areas (on the order of a few hectares) by several constraints, including representation of the soil with a single profile, the use of point rainfall and weather input, and the relative simplicity of its surface flow network. It is not intended for use where two or more different crops are grown on different parts of the catchment, for example, because that would require more complex spatial simulation of plant growth and hydrology. The model can, however, simulate cases where different crops are grown sequentially, including the case

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where one crop is planted between the rows of another crop not yet harvested.

Wherever possible, as discussed in this volume, default values or tables of suggested parameter values are given to allow the use of the model in the absence of measured data. This includes the difficult-to-measure soil hydraulic parameters and a range of typical parameters for the crop growth model. Input data can be totally in either English or metric units, and the output can also be in either unit system. The computer program operates internally in the metric system.

There are a variety of options for the user to choose, depending both on the detail and type of available weather data and on the user's modeling objective. The various options are summarized in the section immediately following, and then the necessary input file preparation is presented in detail. Following that, some examples are shown to help explain various features.

Opus operates on a range of process time scales, as illustrated in figure 1. The simulation for comparing long-term effects may span many years. For agricultural applications, the longest time scale unit is the rotation period, within which there is a fixed pattern of changing crops and management actions. A shorter important time scale is the annual weather cycle. The various methods of including weather data into Opus are discussed in volume I, and their implementation is outlined below. Within the annual cycle is the daily cycle, which is the time step with which weather information, crop growth, management decisions, and daily rainfall occurrences are treated. Soil water redistribution and evapotranspiration are simulated in internally chosen time subdivisions and are updated on a daily basis.

When rainfall intensity pattern data (here referred to as breakpoint data) are available, there is a finer scale for simulating the time and spatially dynamic process of surface runoff. For this case, Opus simulates hydrographs and sediment production patterns within each runoff-producing storm.

As the hydrologic processes are simulated, the model can simultaneously simulate several other optional, interactive processes. These include erosion and sediment transport, and the application and transport of pesticides and fertilizers. Opus can also simulate the various transformations in the soil organic system, including residue decay and the carbon, nitrogen, and phosphorus cycles. Other optional processes that Opus can simulate include irrigation additions of water, draintile water table controls, and small farm ponds. Selection and implementation of the various options are discussed below.

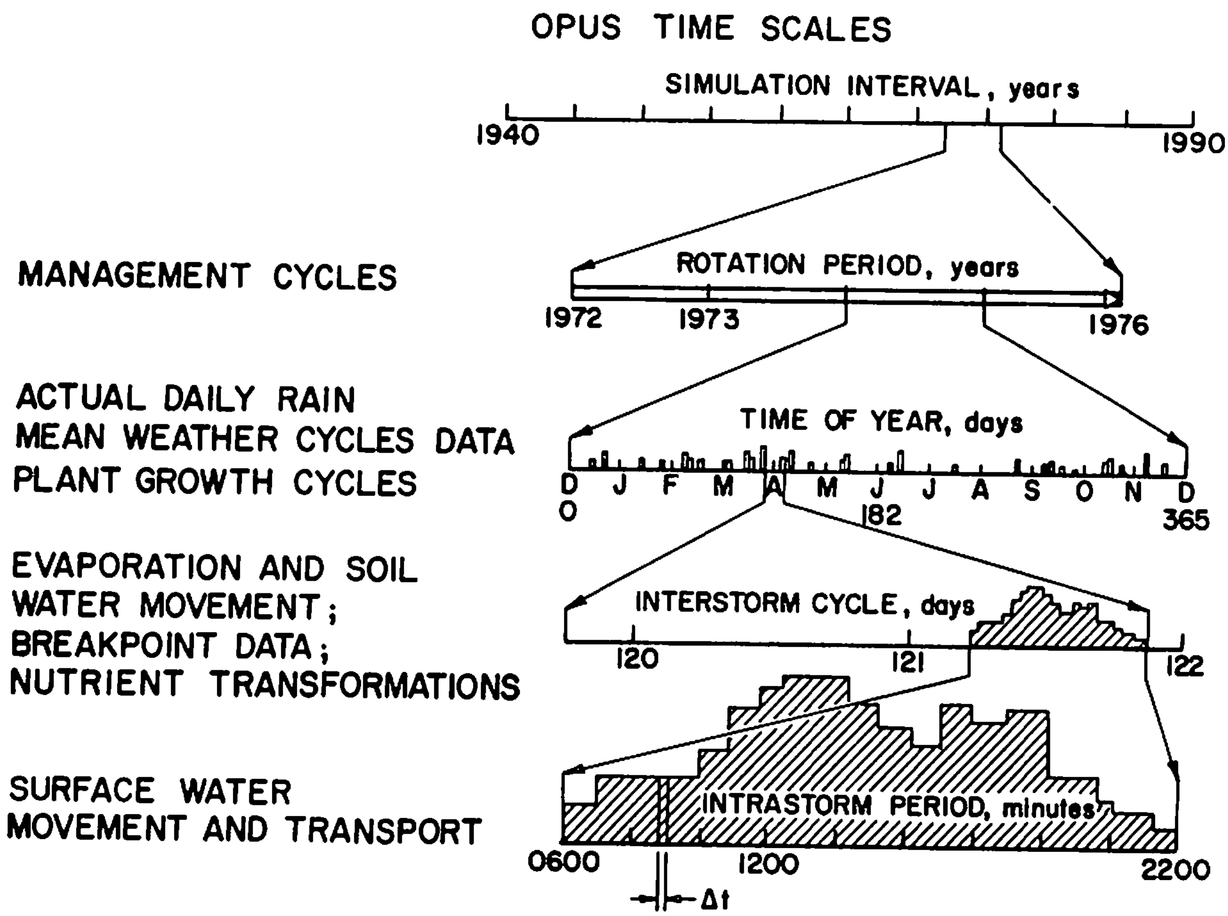

Figure 1. Scheme of the various time scales in Opus.

The general simulation process is diagrammed in figure 2. Here, general processes are shown as units, which in the program may be made up of many subunits or modules. There are several input and output files, referred to below, but not all are necessary for any option. This document is intended as a guide for use of the program, rather than a description of the computer program itself. For those interested in the code, the last three appendixes are included as documentation aids: Appendix E is a glossary of the major code names used in the FORTRAN code, appendix F is a list of the code subprograms and their calls and file locations, and appendix G is a table of COMMON block usage and locations within the various files making up the total code.

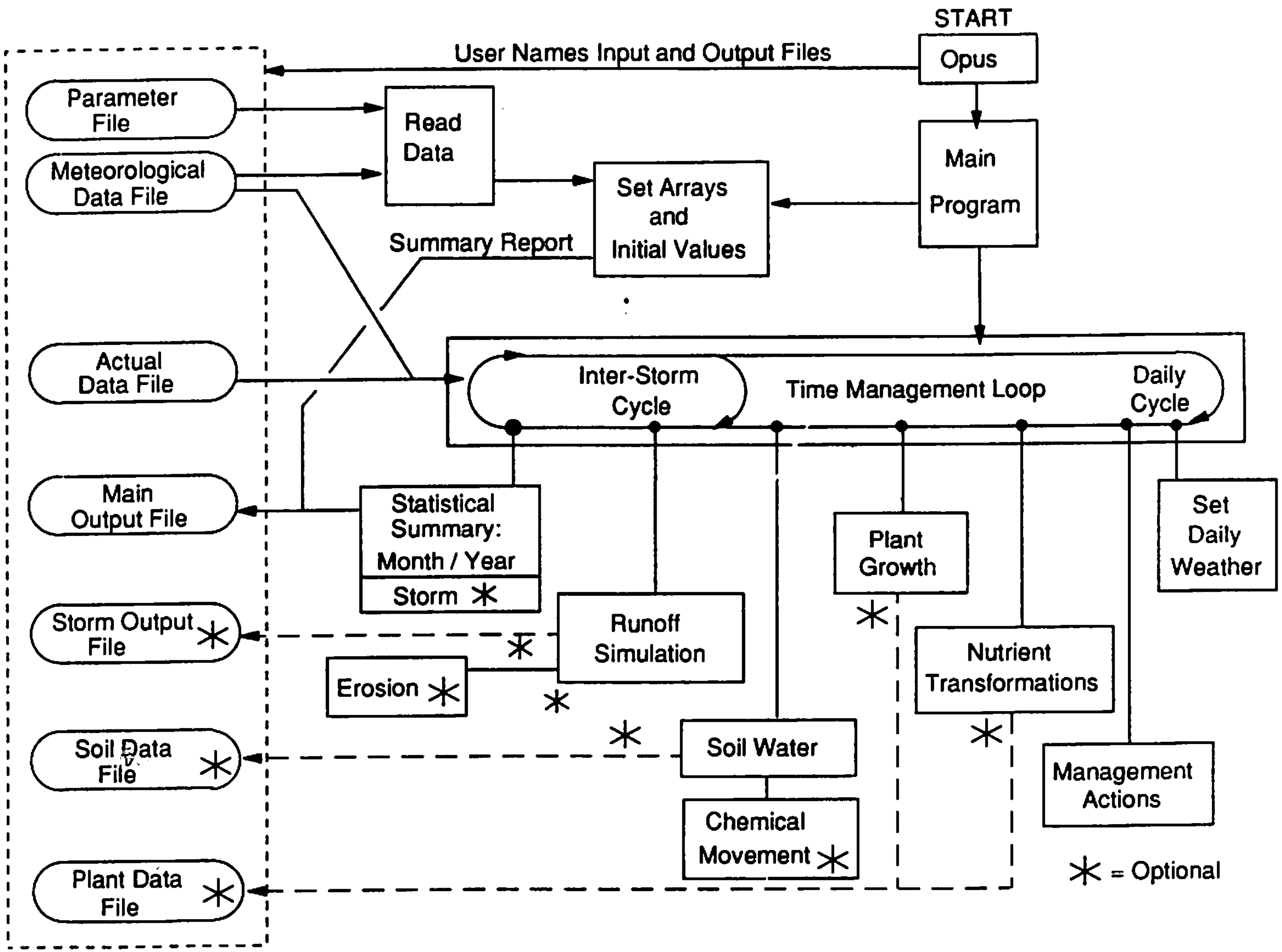

Figure 2. Logical flow diagram of major sections of Opus model.

OPUS OPTIONS: OVERVIEW

For any simulation, the Opus model requires a specification or simulation of the weather and rainfall pattern and also a basic description of the surface and soil features. In any application the model will simulate runoff and soil water inputs and redistribution. Beyond that, there are a large variety of options that the user must choose, with some constraints, and these are outlined below.

Hydrology Options

The most basic option is that of the detail of surface hydrology. In theory, this should be guided by the modeling objective, but in practice, it is often dictated by the available data. When rainfall records either are not available for the local field or are available only in the form of daily rainfall, Opus provides a spatially "lumped" conceptual model to estimate daily runoff and peak runoff rate from daily rainfall. As described in volume I, this methodology is taken with some extensions from the EPIC model (Williams et al. 1984). The features of the two major hydrology options are summarized in table 1.

Table 1.
Hydrology options in Opus

Hydrology option (IHOP)	Rain data	Runoff calculation	Peak runoff	Erosion methodology
1	Daily[1]	SCS CN	Estimated from runoff volume	MUSLE
2	Break-point	Infiltration model	From generated hydrograph	Unsteady, spatially distributed

[1]Daily rain option includes rainfall-generating capability if daily data are not available.

Breakpoint Hydrology. When data on rainfall rate distribution are available, Opus can simulate runoff amount and distribution with a more physical basis, including time and spatial distribution of runoff and erosion rates. Figure 3 illustrates schematically a typical trace of accumulated depth of rainfall versus time, for a continuously recording raingage. The interpretation of this graph locates points at each observed break in slope. The resulting record of rain rate and time pairs is called a breakpoint record. This common term is herein used to refer to all rainfall intensity data, even if obtained from a digital, tipping bucket or other similar type of gage.

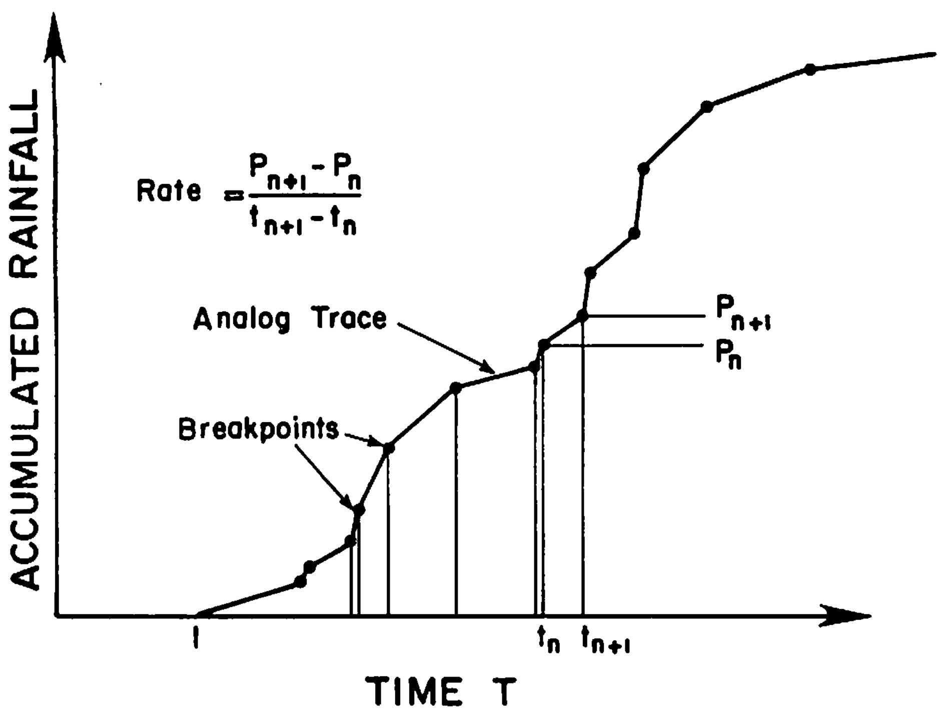

Figure 3. Definition drawing of interpretation of a trace of accumulated rainfall versus time. Change in slope is change in rain rate, and points of slope change are termed "breakpoints."

<u>Daily Hydrology Options</u>. Within the daily hydrology option, there are several options depending on data availability. These are shown diagrammatically in figure 1 of volume I. In the absence of recorded data, a stochastic weather generation model and its necessary parameters are included. In principle, weather parameters can be developed for any place with weather records of sufficient length. Parameter maps and tables given in appendix D allow the generation of stochastically reasonable sequences of rainfall for any place within the map limits (continental United

States), for use where local data are not available. If actual runoff and erosion data are available, their use can obviate modelling of runoff and erosion, thus reducing the uncertainty for dependent processes.

For either generated or measured daily rainfall data, the user can choose to use either the Curve Number estimate of daily runoff or a stochastic variation of it (see vol. I, ch. 5).

Sediment Transport Methodology

The sediment transport option is closely linked with the hydrology option. For the daily hydrology option, an appropriate lumped estimate of sediment production is used (MUSLE, Williams 1975). This method utilizes the estimated volume and peak rate of runoff to estimate a daily amount of sediment loss. In the daily option, most of the physical details of the catchment (such as slope patterns and flow lengths) are used only indirectly in the estimation of peak runoff rates and USLE slope-length factors. For the breakpoint hydrology option, erosion and sediment transport are treated simultaneously with the routing of surface water, in a spatially and temporally distributed manner. All topographic information is therefore utilized in the simulation. This option includes the simulation of deposition in any pond that may be part of the catchment topography.

Agricultural Chemical Options

Two major chemical process options may be selected by the user. These are nutrient simulation (soil residue, nutrient cycling, and nutrient movement) and pesticide fate (addition, decay, and movement of agricultural pesticides).

<u>Nutrient Cycling and Transport</u>. The nutrient/soil plant residue model includes carbon, nitrogen, and phosphorus cycling in soil and residue, plus soil water transport of soluble nutrients in the root zone and nutrient additions to runoff (Parton et al. 1988). For this option, the user should specify initial soil organic composition as well as any nutrients added as fertilizers.

<u>Pesticide Application and Transport</u>. The pesticide model allows simulation of the fate of as many as ten different applied pesticides. Application may be aerial (distributed between plant and soil surfaces), directed on, or injected into the soil. Pesticide decay coefficients and soil adsorption ratios need to be specified, and the user may choose to simulate equilibrium adsorption or kinetic adsorption dynamics. Radionuclides may be treated similarly as an additional option.

Other Management Options

Agricultural management actions, other than the application of chemicals mentioned above, are important on agricultural catchments primarily for the changes they make in the hydrology of the catchment. This then indirectly affects all water-related processes that are important to pollution potentials.

Tillage Operations. Tillage operations include those that plant and harvest crops as well as those that only disturb and reshape the soil surface. These operations are significant in the hydrology not only by altering surface roughness and surface soil properties, but also by redirecting the flow of runoff water through the production of furrows and by mixing surface soil and residue into the profile. The user, with guidance from tables contained herein, can specify the properties of the soil surface and the extent of mixing resulting from a wide variety of tillage operations.

Terraces. A more radical management action in terms of surface hydrology is the formation of terraces and the creation of a second-order terrace outlet channel. This is accommodated in the breakpoint hydrology option of Opus, provided the terraces are of reasonably uniform size and spacing. Specification of terrace systems is discussed in the section on data preparation below.

Grass Buffer Strips. The user of Opus may also specify the existence of grassed channels or buffer strips that are not subject to either erosion or management changes and that are often used for erosion control. This management operation is effectively simulated only with the breakpoint hydrology option where runoff spatial variation is simulated.

Irrigation. The Opus user can simulate either furrow or sprinkler irrigation, can simulate the addition of fertilizers or pesticides with irrigation water, and can specify individual irrigations or irrigation when the soil becomes drier than a certain limit.

Draintiles. Opus can simulate the groundwater control actions of perforated drain tubes at a specified spacing and depth.

Farm Ponds. The trapping and storage actions of small ponds at the outlet of a catchment can be simulated in an approximate manner by Opus. For the breakpoint hydrology option, this simulation is based on the geometry of the pond and the hydraulics of the outlet. In the daily hydrology method, the treatment of ponds is limited to changes in the lumped parameters representing management effects on sediment production.

Weather Data Options

In addition to the daily rainfall options outlined in the daily hydrology model above, there are other options for supporting meteorological data that are linked in some cases to the available rainfall data.

Statistical Generated Data. The WGEN stochastic model for daily rainfall includes parameters for the generation of correlated values of daily maximum and minimum temperatures and daily incoming solar radiation (Richardson and Wright 1984). The parameter maps for the generating model are reproduced in appendix D of this volume.

If the user has monthly weather summaries (temperatures and radiation means) that are more particular to the location of interest, the model can use that information to modify the generated sequence to match the monthly mean values of actual records.

The user can choose to generate a smoothly changing sequence of daily temperature and radiation data, with each day representing the long-term record average, or that smooth series can be stochastically varied to make a more realistic record. The resulting record is still correlated with the rainfall record.

Use of Actual Runoff and Weather Records. Another option in Opus allows the user to enter and use actual daily observations of maximum and minimum daily temperatures and radiation, plus (if available) recorded runoff amounts, peak rates, or daily sediment production. The hydrologic records allowed are only daily values for the daily hydrology option. This option allows a user to focus the simulation on dependent processes, such as soil water transport or crop growth. This can reduce the hydrologic uncertainty in the case where there are experimental records.

Other Options

Input/Output Units. The user may input data in either English units or metric units. The subsequent input data description in this volume gives appropriate units for each option. The units cannot be mixed. Similarly, the user may select either system of units for the output from the program.

Output Options. Opus provides the user with a range of output options, based on time scale of interest as well as the object of the simulation. Up to four different output files are possible: one basic and three optional. The basic output contains some input summary information, monthly and annual hydrologic balance summaries, and any run warnings or user notices generated by the model's reaction to the input data. This output file may optionally include storm or daily summaries on all days with rainfall.

The first optional output file contains detailed surface hydrology data, useful principally with the breakpoint hydrology option. For this option, the file contains hydrograph distributions of rain rate, runoff rate, and sediment concentrations throughout the storm. This output file is chosen by specifying a threshold value of rainfall, below which smaller storms are not reported. The second optional output file contains reports of soil water and solute distributions at a user-specified interval (days), plus an annual summary of pesticide fate, by month. The interval report includes pesticide and nutrient concentrations for each soil computational interval within the root zone. The solutes may be optionally reported in either mass per unit area or concentration by weight of soil. The third output file may contain a summary of plant status for as many as four different plants used in a rotation, or it may contain summary data by month of soil nutrient and residue pools.

The optional major processes and output files are chosen at the beginning of a simulation run by an interactive selection process.

DATA PREPARATION FOR OPUS

General Information

The data input to Opus is organized into functional or topical groups. Data are normally read from two files; one contains meteorological information, and the other contains parameters describing the field and management. A third input file may be used to provide real measured data, to obviate certain hydrologic simulations (e.g., daily temperatures, runoff volume and peak, and erosion amounts). A section below entitled "Running Opus" describes the file selection and information needed for system commands. Opus is furnished for use on an IBM-compatible personal computer, and some modifications may be required to run it as a batch program on a mainframe computer.

Opus parameters and meteorological statistics are input in the form of template files, samples of which are provided with the program. Henceforth the term "line" is used to indicate a single input record. Each input data line is preceded by a prompt line containing the variable names, which we refer to as a template. Data must be entered in the field beneath their name, right justified (ending in the column where the name ends). Except where otherwise noted, parameter values are limited to seven digits (including the decimal point), and line formats are most often constructed to allow seven characters per parameter. Parameter names follow the standard FORTRAN convention: Integer names begin with I-N, and floating point variables begin with A-H and O-Z. Integer variables cannot contain decimal points in the parameter file.

The sample template files provided with the program contain a set of necessary input data lines, including several examples of "repeats": When the number of input lines varies (e.g., descriptions of a variable number of pesticides, or numerous nutrient application dates), both the data line and its prompt or template line must be duplicated. Entire blocks of data may need to be repeated (e.g., there must be a complete management data set for each rotation year).

Input parameter and meteorological statistics data lines are identified in columns 78-80 with a letter corresponding to the data type and a two-digit number for the line number within the data type. The identifying letters must be capitalized, and the numbers must contain two digits (include a leading zero for one-digit numbers), e.g., A03. These identifiers must remain in columns 78-80 after the data line is filled with data by the user. This is necessary to provide checking of data as they are read. Precipitation data and the file of real data input are an exception to this rule.

Comparisons with CREAMS Data Files. Some Opus input files resemble CREAMS input in function and content. This similarity was maintained to ease the transition for users of CREAMS who may wish to use Opus. GLEAMS input strongly resembles that of CREAMS, its precursor. In addition to the obvious change to template format, several other differences exist, as summarized in table 2. Meteorology files contain initial identification or title data, which are echoed to all output files. The daily precipitation data are much like those in CREAMS except that in Opus they include the year on the first data line of each year. This allows the user to change start dates without modifying the rainfall input file. Because the precipitation input in Opus is very similar to that in the CREAMS format, it is easily converted from the CREAMS format to the Opus format (conversion programs are provided in appendix A). Appendix A contains FORTRAN code and run instructions for programs to convert CREAMS rain data to Opus format, before appending them to a meteorology template file.

Table 2.
Input differences between CREAMS and Opus

Feature	CREAMS	Opus
Rain files:		
Title record	None	1 required
Units	English	English or metric
Daily data-year identified	No	Required on first record of each data year[1]
Breakpoint data	Julian	Julian or calendar
Depth-time line (breakpoint data)	1 pair per record FORMAT(2f8.0)	5 pairs per record FORMAT (10f8.0)[1]
"Measured" data file	None possible	Read if available
Parameter files	1 file for each of 3 programs	1 file for all runs; CREAMS parameter files not directly convertible to Opus format.

[1]See app. A for conversion assistance.

Parameter Data File

The parameter file contains the data necessary to define the problem for simulation. Input data are grouped by general types as listed in table 3. The data input for Opus are identified in the description below using these groups and line numbers within that group. As explained below, some lines, for consistency, are required to be part of a set even if not used by the options chosen.

Table 3.
Opus input data organization

Record group ID	Data type	Input file
A	ID and run controls	Parameter file
B	General state/initial conditions	Parameter file
C	Soil horizons	Parameter file
D	Crops	Parameter file
E	Management	Parameter file
F	Topology	Parameter file
G	Erosion/sediment	Parameter file
H	Climate/weather statistics	Meteorology file
I	Precipitation	Meteorology file
J	Measured data, obviates simulation of process	Actual data file

The flag INUN in the parameter file identifies the input data as either metric or English units. The input data must consistently be in the defined units throughout all input files. The rare exceptions are noted in variable descriptions.

In order to keep data sets of a generally standard configuration, several of the parameter data lines are read but not used when a particular option is not chosen. These lines must always be included in the data file, but they may be left blank when the option is not chosen. This standardization is intended to (a) allow the user to include or exclude an option without needing to make extensive additions and deletions in a data set, and (b) make data set checking more reliable.

The input parameters are summarized in appendix B, a table that contains line-by-line parameter descriptions, required units (English or metric), and default values (if used). The various data groups and their variables are described in detail in the following section "Opus Parameter File," including tables of suggested parameter values for various conditions.

Meteorology Data File

The meteorology file contains statistical parameters and data describing the watershed's climate. Depending on the options chosen, the file may also contain (a) daily rainfall records for years to be simulated, (b) statistical parameters for generating daily rainfall, (c) monthly record statistics for generating daily temperature and/or radiation, or (d) breakpoint rainfall records for the period to be simulated.

The meteorology data file consists of a template section containing weather statistics, and an optional rainfall data section. Most of the weather statistics are necessary for all simulations, to determine daily air temperatures and radiation values used in the models for crop growth, evapotranspiration, and soil processes. Tables and maps of necessary statistics for many locations in the United States are provided in appendix D.

The required rainfall input depends on the hydrologic option chosen and the type of rainfall data available to the user. Hydrology option 1, using SCS Curve Number runoff methodology, requires information on daily total rainfall. This may be input for the simulation period or may be generated within Opus from the statistical information in the meteorology template section. The user's objectives determine the necessity of daily input data, including daily temperatures and radiation. For validation simulations (comparing model results to observed data), supplying all available real data is rewarded by minimized model errors. However, for long simulations (50-100 years, for example), generated meteorological data require very little input and produce very reasonable results.

Hydrology option 2 uses infiltration-based runoff methodology and requires the user to input stormwise breakpoint information. Breakpoint data consist of cumulative time-depth pairs at points of rate change on the rainfall record. The space scales of Opus necessitate input data with a time scale of about a few minutes to produce reasonable runoff estimates with the infiltration model. The "Opus Meteorology File" section describes meteorological input in detail.

Actual Data File

The actual data file is optional. It contains any or all of the following daily data: measured runoff, peak flow, storm erosivity index (EI), total storm sediment delivery, recorded daily maximum and minimum temperatures, and daily solar radiation. If an actual data file is called for, Opus assumes that it contains at least daily maximum and minimum temperatures. The user may input daily values of these meteorologic and hydrologic variables to obviate simulation of particular processes. The section entitled "Actual Data File" describes the measured data file in detail.

OPUS PARAMETER FILE

This section describes the input parameters in some detail, including suggested ranges of values and subjective guidance when possible. A better understanding of their function can be obtained by reference to volume I. Appendix B is a tabular summary of the Opus parameter input data. Table 4 lists the formats with which parameter file data lines are read. Appendix C contains a sample parameter template file.

Table 4. Parameter file formats

Line	Format	Line	Format
A01	(a80)	E09	(i7,8f7.0)
A02-A04	(10i7)	E10	(i7)
		E11	(i7)
B01-B02	(10f7.0)	E12	(i3,i4,i7,5f7.0)
B03	(5i7)	E13	(i7)
		E14	(i3,i4,i7,3f7.0,i7,2f7)
C01	(i7)	E15	(i7)
C02-C03	(10f7.0)	E16	(i3,i4,217,5f7.0)
		E17	(i7,i3,i4,i7,5f7.0)
D01	(2i7)		
D02	(a3,a4,i7,8f7.0)	F01-F02	(10i7)
D03-D04	(10F7.0)	F03-F04	(10f7.0)
		F05	(i7)
E01	(f7.0)	F06	(10f7.0)
E02	(i7)	F07	(3i7,7f7.0)
E03	(a3,a4,2i7,5f7.0)	F08	(10i7)
E04	(i7)	F09-F10	(10f7.0)
E05	(a3,a4,9f7.0)	F11	(i7,9f7.0)
E06	(10f7.0)		
E07	(10f7.0)	G01	(i7)
E08	(i7)	G02-G04	(10f7.0)

Each input data line must contain an identifying code (e.g., E06) in columns 78-80. Opus reads and checks these codes, writes an error message on the standard output file, and stops if the expected code is not read in. The error message indicates both the expected and read codes. Error messages are most likely to occur when simulations deviate from the sample template run in the number of input lines, e.g., if more pesticide transports are simulated than were in the sample run. Such runs require the user to duplicate portions of the template; the user should always include both header lines and input data lines. If input is done incorrectly, the program reading will immediately be out of synchronization; for instance, the program reading will show data lines when the user is expecting headers. Prior experience indicates that if the program does not check and stop, such errors result in either obscure system messages and a system-aborted run or erroneous results.

The following describes parameters by input line within each data group (as summarized in appendix B).

Group A. Title, Run Controls, and Options Flags

Input group A identifies the simulation and determines which input, output, and simulation options are to be used.

A01: TITLE(J)

Three lines of identifying information (A01) are read. These data are written to output files so that the user can identify all output from particular runs. Opus does not interpret the title information; it just reads and writes it. It is useful to fill these lines with information distinguishing the run from other runs (e.g., which parameters have been changed and the values used, such as "CURVE NUMBER = 76" or "No-nutrient run") to avoid confusion when analyzing several output files.

A02: IBMO, IBDA, IBYR, IEMO, IEDA, IEYR, IFWRDA, INTSP, ICON, THRESH, IRYR

The A02 line contains simulation period information and a management timing parameter. A free format is used since this line is a revised record to allow for 4-digit years. At least one space must be allowed between numbers, and THRESH must have a decimal point.

IBMO,IBDA,IBYR describes the month, day, and year (MM/DD/YYYY) of the simulation. Initial conditions described on B02-B03 refer to this date. IRYR should be the management year for this start date. Simulation start may be any time in the year but must be inside the period of rainfall data. It is usually more practical to start prior to perennial plant activity.

IEMO,IEDA,IEYR gives the date of the simulation end, (MM/DD/YYYY). If breakpoint rainfall is used, a rainfall event for at least one day beyond this date is needed (Opus reads ahead for length and interval calculations)

IFWRDA — Flag controlling output to terminal or log file during simulation.

IFWRDA=0 No screen output.
IFWRDA=1 Date [yyddd] is written to screen as day's information is processed. For long batch run simulations, this option will create unnecessary massive batch output files.

INTSP — Time increment of output to soil-layer file [days]. (See "Opus Output Options" section for complete description of output files.)

INTSP=0 No soil-layer information output.
INTSP=1 Output daily.
INTSP=31 Output each month (of whatever size).
INTSP=365 Output annually.
INTSP=n Output every n days, where n is any integer except 31 or 365.

ICON — Flag switching soil-layer output from mass to concentration for all chemical variables. Used only if INTSP>0.

ICON=0 Output in units of mass/unit surface area.
ICON=1 Output in units of concentration.

THRESH — Storm file threshold for stormwise output. Depth of rainfall below which output is not wanted [mm or in]. In English units, for example, 0.01 inches would probably yield output for all storms (depending on precision of rain data input), whereas 2.0 or 3.0 in would cause output for only large storms.

IRYR — Rotation year to be used for first year of simulation, from the ordered listing in management scheduling list (E11-E18). IRYR must of course be ≤ NYROT (E10).

A03: INUN, IOU, IHOP, IPAN, IFOUT, IFRAN, IFRNCN, ITOCH, IFREAL

INUN — Flag indicating units system of all input data. Appropriate units for the two systems, for each data item, are listed in appendix B and are also noted in the following text in description of each variable. Note that one cannot switch between systems within a simulation.

INUN=1 Metric units on all input data.

INUN=2 English units on all input data.

IOU — Analogous to INUN, but refers to values on all output files.

IHOP — Flag to indicate which hydrology option is used.

IHOP=1 Daily rainfall (either real or generated) with curve number runoff methodology.

IHOP=2 Breakpoint rainfall with infiltration-based runoff methodology.

IPAN — Flag indicating use of pan evaporation data instead of solar radiation input. This flag controls the interpretation of line H12 data.

IPAN=0 Meteorological simulation is to be based on monthly input data of incident solar radiation.

IPAN=1 Meteorological simulation is to be based on monthly mean values of daily pan evaporation and a pan coefficient (COEFF on line H13).

IFOUT — Flag specifying output option to be written on standard (mandatory) output file. IFOUT is used to specify type of information written. Output options are discussed in detail in the section "Opus Output Options."

IFOUT=0 Only monthly and annually summarized output are to be written. (Refer to fig. 24 for illustration of this standard output file.)

IFOUT=1 Results are to be written after each storm, in addition to monthly and annual summaries. (Refer to fig. 25 for illustration of standard output file with stormwise results written.)

IFRAN — Controls the randomization of daily temperature and radiation values. With or without this option, the program generates a gradually changing sequence of average daily temperature and radiation data, representing average long-term daily values for each day.

IFRAN=0 Mean meteorological data are used for each year of simulation, making every year an average year, in effect. Deviations from smooth curve are based on wet/dry occurrences.

IFRAN=1 Daily temperature and radiation values are randomly varied about their means (including logical correlations with each other and with rainfall).

IFRNCN Controls randomization of runoff values predicted by Curve Number method (see vol. I, ch. 5); applies only to daily hydrology option (IHOP=1).

IFRNCN=0 No randomization.

IFRNCN=1 Curve number predictions randomized.

IFREAL Flag used to signal presence of any recorded daily data that are to be used in place of simulated data for one of the daily options. These data include any or all of the following: runoff, peak flow, sediment production, erosivity index (EI) for storm (day), maximum and minimum daily temperatures, and daily incoming solar radiation.

IFREAL=0 No measured data available to obviate simulation.

IFREAL=1 Measured data provided; a third input file must be assigned.

A04: IFSED, IFNUT, IFPEST, IFIRR, IFPOND, IFDRAN, IVARK, IFT, IFGEN

IFSED Flag to indicate simulation of sediment transport within and from the field.

IFSED=0 Simulation of erosion and sediment transport is to be bypassed.

IFSED=1 Sediment option is to be included. Should be used when simulating transport of pesticides or nutrients because of interactions.

IFNUT Flag to indicate simulation of nutrient processes, including simulation of nutrient additions, transformations, and transport in water. For accurate prediction of surface water nutrient deliveries, IFSED should be 1 when IFNUT is 1 or 2.

IFNUT=0 Simulation of nutrient processes is bypassed.

IFNUT=1 Nitrogen additions, movement, and transformation processes are simulated.

IFNUT=2 Both nitrogen and phosphorus processes are simulated.

IFPEST — Flag to indicate simulation of pesticide or radionuclide processes:

- IFPEST=0 — No pesticide or radionuclide processes are simulated.
- IFPEST=1 — Pesticide additions, decay, washoff, and transport are simulated.
- IFPEST=2 — Radionuclide processes are simulated. Chemical characteristics of radionuclides can be treated much like those of pesticides, but some differences are recognized in the model. Radionuclides can be adsorbed on inorganic matter. They are subject to decay and adsorption phenomena as are pesticides, although radionuclide decay is not affected by temperature and water content as is pesticide decay.

IFIRR — Flag to indicate if irrigation is to be simulated:

- IFIRR=0 — No irrigation is to be simulated.
- IFIRR=1 — Sprinkler irrigation is to be simulated.
- IFIRR=2 — Furrow irrigation is to be performed according to need, using demand-controlled supply.
- IFIRR=3 — Furrow irrigation is to be performed according to a fixed schedule, e.g., using a ditch supply.

IFPOND — Flag indicating the farm pond or impoundment into which field runoff flows and the geometric model of the pond to be applied:

- IFPOND=0 — No pond present.
- IFPOND=1 — Pond is present and described by a three-parameter relation of depth to surface area (see line F11).
- IFPOND=2 — Pond is present and its geometry is found from slopes of channel, lateral contributing planes, and slope of dam face.

IFDRAN — Flag indicating simulation of tile drainage:

- IFDRAN=0 — No tile drainage present.
- IFDRAN=1 — Tile drains are present.

IVARK — Flag indicating that data on stepwise changes in USLE K are described on F05-F06:

IVARK=0 USLE K assumed to be constant along field.
IVARK=1 Pairs of distance and K values to be read.

IFT Indicates whether data on actual recorded mean monthly weather variables are to be read and used to control mean generated monthly values. Included are maximum and minimum temperatures and radiation values.

IFT=0 No average monthly weather data to be read.
IFT=1 Monthly recorded mean values of daily maximum and minimum temperatures are to be read.
IFT=2 Like IFT=1, but monthly recorded mean values of daily radiation or pan evaporation are to be read also.

IFGEN Indicates whether daily rainfall data are to be read from meteorology file or generated by Opus. IFGEN applies only if IHOP=1 and is ignored when IHOP=2.

IFGEN=0 Daily rainfall data for simulation period are to be read from meteorology file.
IFGEN=1 Daily rainfall data are to be generated from climate statistics in meteorology file.

Group B. General State and Initial Condition Parameters

Group B inputs define the general state and initial condition of the field. When changing the simulation start date (IBDATE, line A02), it may be necessary to modify some of the group-B parameters accordingly. Initial moisture status, surface roughness, and current crop are among the important initial conditions, and these may change with starting date.

B01: DA, DWTB, GLAT, CN2, PHRN, CONRN, DASL, ALBS, FWIND

DA Total field area [ha or acre (henceforth abbreviated ac)].

DWTB Depth to the uppermost permanent water table [m or ft]. If tile drains are used, this parameter is the mean depth to the tile drain inverts.

GLAT — Latitude of field location. Positive latitudes are in Northern Hemisphere; negative latitudes refer to Southern Hemisphere [degrees and fraction of degrees; e.g., 32°30" is entered as 32.5].

CN2 — SCS AMC Class II curve number. May be zero or blank for breakpoint runs. Table 5 lists curve numbers for various field conditions.

PHRN — Rainfall pH. A reasonable value is 5.6. (The July 1992 version of Opus does not use this parameter.)

CONRN — Typical or annual mean concentration of N in natural rainwater [mg/L or ppm]. A typical value is 0.8.

DASL — Surface-soil depth that can be considered to effectively interact with the surface-runoff water in the exchange of chemicals among soil-solution, soil-adsorbed, and runoff-solution phases. This parameter is important in the calculation of washoff of pesticide and nutrient material. A useful estimated range of values is 3-10 mm. It should be a function of tillage depth and/or random roughness, and should not be larger than 10 mm [mm or in].

ALBS — Albedo of the field's bare dry soil (expressed as a decimal fraction). Albedo is defined as the fraction of incident solar radiation that is reflected by the ground. Albedo varies with soil color. Ranges for various soils are

Light sand	0.25-0.45
Clay or gray	0.25-0.35
Dark clay	0.14-0.20
Dark soil	0.05-0.15

FWIND — Parameter used in calculation of potential evapotranspiration (ET). It reflects the combined effects of wind and humidity on ET. Default value is 0.28. This parameter exists primarily for use in ET investigations; otherwise the default should be used.

Table 5.
Runoff curve numbers for hydrologic soil-cover complexes, assuming antecedent moisture condition II and $I_a = 0.2S$[1]

Land use	Treatment or practice	Hydrologic condition	Hydrologic soil group A	B	C	D
Fallow	Straight row		77	86	91	94
	Strt.row + conserv.till.	Poor[2]	75	84	89	92
	Strt.row + conserv.till.	Poor[3]	74	83	87	90
Row crops	Straight row	Poor	72	81	88	91
	Straight row	Good	67	78	85	89
	Strt.row + conserv.till.	Poor[2]	71	79	86	89
	Strt.row + conserv.till.	Good[3]	64	75	82	85
	Contoured	Poor	70	79	84	89
	Contoured	Good	65	75	82	86
	Contoured + conserv.till.	Poor[2]	69	78	83	87
	Contoured + conserv.till.	Good[3]	61	70	76	79
Small grains	Straight row	Poor	65	76	84	88
	Straight row	Good	63	75	83	87
	Strt.row + conserv.till.	Poor[2]	64	74	82	86
	Strt.row + conserv.till.	Good[3]	60	72	80	84
	Contoured	Poor	63	74	82	85
	Contoured	Good	61	73	81	84
	Contoured + conserv.till.	Poor[2]	62	73	81	84
	Contoured + conserv.till.	Good[3]	60	72	79	82
	Contoured + terraces	Poor	61	72	79	82
	Contoured + terraces	Good	59	70	78	81
	Cntrd. + ter. + con.till.	Poor[2]	60	71	78	81
	Cntrd. + ter. + con.till.	Good[3]	58	69	76	79
Close-seeded legumes[4] or rotation meadow	Straight row	Poor	66	77	85	89
	Straight row	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	Contoured	Good	55	69	78	83
	Contoured + terraces	Poor	63	73	80	83
	Contoured + terraces	Good	51	67	76	80

Table 5--Continued.
Runoff curve numbers for hydrologic soil-cover complexes, assuming antecedent moisture condition II and $I_a = 0.2S$[1]

Land use	Treatment or practice	Hydrologic condition	Hydrologic soil group A	B	C	D
Pasture or range	--	Poor	68	79	86	89
	--	Fair	49	69	79	84
	--	Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	Contoured	Fair	25	59	75	83
	Contoured	Good	6	35	70	79
Meadow	--	Good	30	58	71	78
Woods	--	Poor	45	66	77	83
	--	Fair	36	60	73	79
	--	Good	25	55	70	77
Farmsteads	--	--	59	74	82	86
Roads[5]	Dirt	--	72	82	87	89
	Hard surface	--	74	84	90	92

[1]Adapted from Rawls and Richardson (1983).

[2]Residue cover is less than 20% of surface (less than 750 lb/acre for row crops or 300 lb/acre for small grain).

[3]Residue cover is more than 20% of surface; normal range is 20%-40%.

[4]Close-drilled or broadcast.

[5]Including right-of-way.

B02: SRESD, STDRY, THST, ROWSP, DPFR, RGSURF, ZSF, DTILL

SRESD — Amount of plant residue on soil surface at beginning date of simulation [kg/ha or lb/ac].

STDRY — Amount of dead plant dry matter standing above soil at beginning of simulation. This material can drop and become surface residue, and is to be distinguished from permanent stalks or trunks and tree branches of perennial plants (which are described as COVI, below) [kg/ha or lb/ac].

THST — Mean initial soil water content of surface soil horizon, by bulk volume [mm/mm or in/in]. This must be within limits THS(1) and THR(1) [θ_r] (see data form C02). THR(1) is calculated from other soil data, and THST is adjusted to be above THR(1) if necessary.

ROWSP — Mean row spacing of furrows, if any, on the field at start of simulation [m or ft].

DPFR — Depth of furrows, if any, at start of simulation [cm or in]. If zero, the program logic assumes that the topography of untilled, natural contours (see group-F data below) applies initially.

RGSURF — Random roughness height of soil surface at start of simulation [mm or in]. This parameter refers to roughness on the scale of that produced by tillage (see variable RFT on line E03). Typical values of this parameter are given in the tillage-operations data (see E section, below, and table 9).

ZSF — Initial side slope of field furrows, as a ratio of horizontal to vertical dimensions. If left blank, a value of 1.5 is assumed.

DTILL — Maximum depth of tillage or the depth to a plowpan, if any [cm or in]. This value overrides the maximum value of PLOWD for the rotation (read below, line E03). If positive, this value is used as an erosion-depth limit.

B03: NC, ICR(I)

Line B03 contains information on crops that are growing or dormant at the beginning of the simulation. These include perennials or dormant winter crops planted the previous fall. If NC>0, care must be used when changing the simulation start date

(IBDATE on line A02). The crops specified to be active at the start of simulation should be consistent with those planted before the start based on the rotation year (IRYR, line A02).

NC — Number of crops (plant species) "active" at simulation start. Maximum is four.

ICR(IRYR,I)(I=1 to NC) — List the crops present at start of simulation, given as one-digit numbers indicating the crop's rank in the sequential crops list (D data lines). For example, if two crops are present, the first and fourth in the D-section input, this line is as follows:

NC	ICR	ICR
2	1	4

Group C. Soil Horizon Data

The set of lines for soil horizon data specifies the differentiated soil horizons in the typical root zone, and specifies the necessary soil physical and chemical parameters for each horizon. Table 6 contains reasonable values for some of these parameters for general soil texture classes.

C01: NSL — Number of horizons, up to six. NSL sets of lines C02-C03 are read for each horizon.

C02: GZH(L), POR(L), PSAND(L), PSILT(L), PCLAY(L), RC(L), B15(L), PBUB(L), ALAM(L), THS(L)

GZH(L) — Depth to bottom of horizon L [mm or in]. First horizon must be at least 20 mm deep.

POR(L) — Natural porosity of untilled soil L, by volume; usually within range of 0.30-0.55 [mm/mm or in/in].

PSAND(L) — Proportion of sand-sized particles in the soil.

Note: The parameter PSILT(L) is redundant insofar as it is obtainable by difference from values of PSAND(L) and PCLAY(L), and thus it may be blank or in error without effect.

PSILT(L) — Proportion of silt-sized particles in the soil.

PCLAY(L) — Proportion of clay-sized particles in soil L. This value is used in various chemical transport and adsorption functions. Unless IFPEST and IFNUT are both zero, a value of PLCAY must be given for all soils, even though value of PSILT is omitted.

Table 6.
Estimated soil hydraulic parameter means and ranges by USDA texture class[1]

USDA texture class	Porosity (mm/mm)	PSAND	PSILT	PCLAY	RC[1] (mm/hr)	B15[1] (mm/mm)	PBUB[1] Arith (mm)	PBUB[1] Geom (mm)	ALAM[1] Arith	ALAM[1] Geom
Sand	0.437 0.347-0.500[2]	0.90	0.05	0.05	210	0.033	159.8	72.6	0.694	0.592
Loamy sand	0.437 0.368-0.506	0.84	0.09	0.08	61	0.055	205.8	86.9	0.553	0.474
Sandy loam	0.453 0.351-0.555	0.60	0.25	0.15	26	0.095	302.0	146.6	0.378	0.322
Loam	0.463 0.375-0.551	0.45	0.35	0.20	13	0.117	401.2	111.5	0.252	0.220
Silt loam	0.501 0.420-0.582	0.20	0.60	0.20	6.8	0.133	508.7	207.6	0.234	0.211
Sandy clay loam	0.398 0.332-0.464	0.55	0.20	0.25	4.3	0.148	594.1	280.8	0.319	0.250
Clay loam	0.464 0.409-0.519	0.35	0.30	0.35	2.3	0.197	564.3	258.9	0.242	0.194
Silty clay loam	0.471 0.418-0.524	0.15	0.50	0.35	1.5	0.208	703.3	325.6	0.177	0.151
Sandy clay	0.430 0.370-0.490	0.50	0.10	0.40	1.2	0.239	794.8	291.7	0.223	0.168
Silty clay	0.479 0.425-0.533	0.10	0.45	0.45	0.9	0.250	765.4	341.9	0.150	0.127
Clay	0.475	0.20	0.30	0.50	0.6	0.272	856.0	373.0	0.165	0.131

[1]RC, B15, PBUB, and ALAM values after Rawls et al. (1982). The columns under PBUB and ALAM are the sample arithmetic and geometric means for these parameters.
[2]Ranges found in raw porosity data are given underneath the means.

The parameters RC(L), B15(L), PBUB(L), ALAM(L), and THS(L) describe the hydraulic properties of the soil--specifically, the relations between water content, capillary suction, and hydraulic conductivity. The functional relations or soil retention and hydraulic conductivity are described in volume I, chapter 2. The relations are a modification of those of Brooks and Corey (1964). The shape of the function is illustrated in figure 4. Some of the necessary information is available for many soils but is not necessarily published in terms of the parameters of the function used here. A related popular retention relationship is that of Van Genuchten (1980). The parameter n of Van Genuchten is related to ALAM (λ) as λ = 1-n, and the parameter α of Van Genuchten is 1/PBUB (except that α is usually in units of cm^{-1} rather than mm^{-1}).

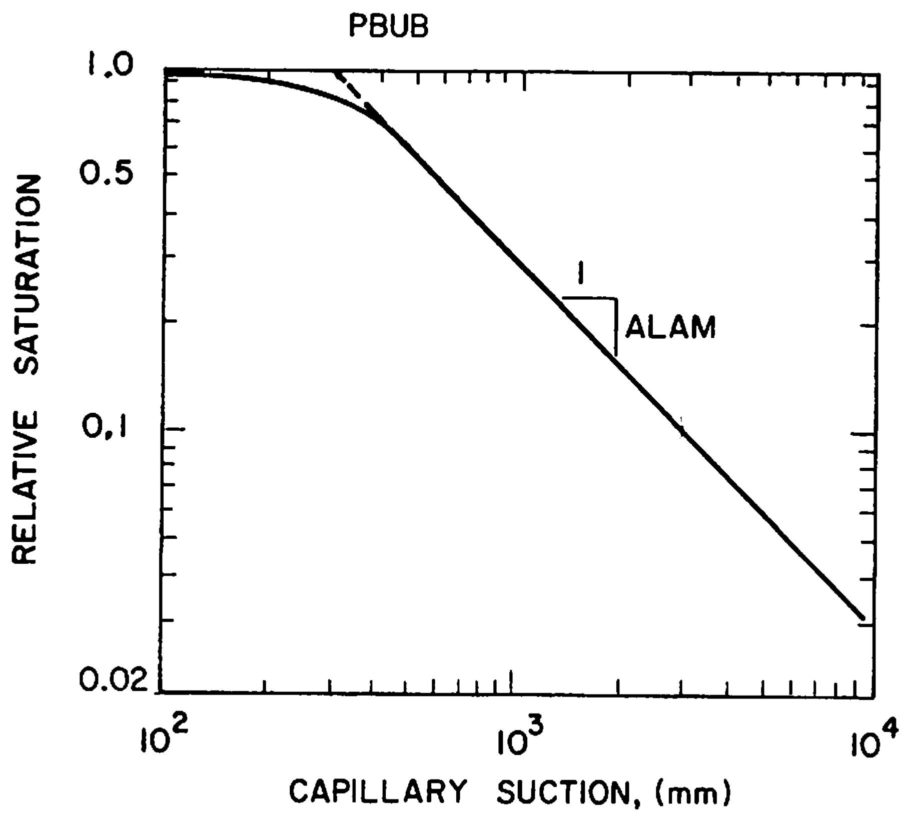

Figure 4. Capillary water retention curve showing graphical meaning of the parameters PBUB and ALAM.

These soil hydralulic parameters may be estimated by the user from texture-class information compiled by Rawls et al. (1982) (included here in table 6). Table 6 shows the general trends in magnitude of these parameters as related to soil texture (with some exceptions). As texture varies from clay to loam to sand, the parameters tend to change as follows:

(a) RC increases;
(b) ALAM increases;
(c) PBUB decreases;
(d) B15 decreases;
(e) Porosity (POR) will change with other factors, such as organic matter and degree of aggregation.

An alternative method (default option) for estimating these parameters is included in Opus: If a negative value is read for any of these, that parameter is estimated by regression functions dependent on sand, silt, and clay contents and on porosity. This optional methodology was developed by Rawls et al. (1982). Such regressions are very generalized and should not be relied on if data that are specific to the location are available. This default option cannot be used if the sand fraction is less than 0.05 or greater than 0.70, or if the clay content is less than 0.05 or greater than 0.60. A more detailed discussion of these parameters and their function is found in volume I.

RC(L) — Saturated hydraulic conductivity of horizon L, in units of flux [mm/hr or in/hr]. Negative value causes default value to be calculated (see caution above). A zero-value input produces a warning message, but no default value is calculated.

B15(L) — Water content of horizon L [mm/mm or in/in] at 15 bars of matric capillary tension. This value is often measured in the course of soil testing (see Holtan et al. 1968, for example). Negative value causes a default regression value to be calculated.

PBUB(L) — Bubbling pressure or air entry pressure of the soil [mm or in]. Interpreted graphically (as shown in fig. 4), it is the intercept of the line, in logarithmic coordinates, describing the water-content/capillary-tension curve at higher tensions. It is a negative potential, physically, but for convenience the absolute value is input. Table 6 indicates that this parameter varies rather consistently with soil texture, and ranges approximately 75-900 mm. A negative input value causes the default to be calculated.

ALAM(L) Pore size distribution index. As illustrated in figure 4, this is the slope of the asymptotic water content-matric tension curve in logarithmic coordinates. This parameter also varies with soil-texture class, and ranges from approximately 0.15 for clay loams to nearly 1.0 for uniform or very sandy soils (and greater than 1.0 for pure sands). A negative value causes the default value to be calculated.

THS(L) Volumetric soil water content at saturation. Must be equal or less than porosity (POR). A negative input value triggers calculation of the default value from relationship with POR, PSAND, and PSILT.

C03: ORGC(L), SRSDU(L), WNO3(L), WPLAB(L), SPH(L), PKD(L), FEROD(L), OMN(L), OMP(L), TOTP(L)

ORGC(L) Initial organic carbon content of horizon L [% by weight]. If total organic matter is known, organic carbon may be estimated as
(organic matter)/1.732.

SRSDU(L) Initial incorporated plant residue material in soil horizon L [g/t or ppm].

WNO3(L) Soil nitrate content of horizon L [g/t or ppm].

WPLAB(L) Labile phosphorus content of soil horizon L [g/t or ppm].

SPH(L) Soil pH in horizon L. (The July 1992 Opus version does not use this value.)

PKD(L) Isothermal adsorption coefficient for extractable labile phosphorus in horizon L [mL/g; no English units equivalent]. If blank or zero, this parameter is estimated by default from the clay content of the soil.

FEROD(L) Flag used to indicate an erosion-resistant soil for the uppermost horizons.

FEROD=0.0	Layer L is not erosion resistant.
FEROD=1.0	Layer L is erosion resistant.

OMN(L) Organic N present in soil horizon L [ppm]. If negative, the model uses default value determined internally.

OMP(L) Organic phosphorus content in soil horizon L [ppm]. If this parameter is negative, a default value is selected by the program.

TOTP(L) Total phosphorus content of soil horizon L [kg/ha or lb/ac]. If TOTP is negative, the model uses the default value of 5 kg/ha.

Group D. Crop Data

The set of lines for crop data describes all crops grown during the rotation cycle, in terms of physical variables that are translated into parameters for the mechanistic crop-growth model. These plant parameters describe optimal target size and yield, optimum growth-determining temperature, aging rates, and nutrient contents. Example values of these parameters for common crops are given in table 7. The values in this table were obtained by fitting and should not be taken as definitive.

D01: NCROP Number of different crops to be grown in the simulation period, for which data will be read.

Lines D02-D04 are a set, repeated NCROP times. Each crop is assigned an identifying number (J) corresponding to the order in which it is read.

D02: IDCR(J), IPER(J), PLAI(J), DDEM(J), DDMX(J), PDRYM(J), POTY(J), RDP(J), PLIG(J), RLIG(J)

IDCR(J) Seven-character alphanumeric name for crop J.

IPER(J) Flag that indicates the annual/perennial nature of crop J:

- IPER=0 Annual, harvested crops.
- IPER=1 A perennial harvested crop, such as hay.
- IPER=2 A perennial grazed crop, such as a grass pasture.
- IPER=3 A perennial natural (ungrazed) catchment, including all types of pristine catchments.
- IPER=4 An annual (planted) meadow or crop that is harvested only by grazing.

PLAI(J) Maximum leaf-area index for crop J, based on plant projected area (<u>not</u> overall area). (Relative plant shaded area and parameter PPCV(J) together describe relative overall shade area.) PLAI is usually between 1 and 5.

Table 7.
Crop parameters for various crops (English units)

State	Condition	PD	HD	Crop	PLAI	DDEM	DDMX	PDRYM	POTY	RDP	PLIG	RLIG	POTHT	PPCV	TGBM	TGOP	CONVF	DEACT	CONY
MN	PERENNIAL	8/30	7/05	ALFALFA	5.3	230	6000	9000	50	52	0.15	0.10	2.5	0.99	23	85	30	0.01	0.118
NE	IRR SS	5/15	10/10	CORN	5.4	90	2450	24500	11200	42	0.15	0.10	6.8	0.95	47	86	65	0.02	0.018
NE	DRY	5/15	10/10	CORN	4.4	90	2450	14376	5725	42	0.15	0.10	4.8	0.95	47	86	65	0.02	0.018
IA	IRR	4/30	10/29	CORN	5.4	58	2700	25000	10640	42	0.15	0.10	7.2	0.95	47	86	70	0.02	0.018
IA	DRY SS	4/20	10/29	CORN	5.4	58	2700	24327	10224	42	0.15	0.10	7.0	0.95	47	86	70	0.02	0.018
MN	DRY SS	5/15	10/15	CORN	5.4	68	1915	16700	7280	42	0.15	0.10	7.0	0.95	47	86	73	0.02	0.018
KS	IRR LS	4/15	10/29	CORN	5.4	58	3000	27000	12880	45	0.15	0.10	7.5	0.95	47	86	70	0.02	0.018
CO	CORN SIL	4/25	9/10	CORN	5.5	58	2450	72260	9000	45	0.15	0.10	9.1	0.97	47	86	70	0.02	0.018
AZ	IRR	3/28	9/27	COTTON	5.0	54	2365	15250	3050	48	0.15	0.10	5.0	0.95	68	93	50	0.08	0.033
MN	DRY SS	5/19	9/25	SOYBEAN[0]	4.0	58	1875	8570	3000	32	0.15	0.10	3.5	0.95	52	77	22	0.03	0.018
KS	IRR LS	5/28	10/20	SOYBEAN[4]	4.2	116	2705	13400	4500	32	0.16	0.10	3.8	0.95	54	77	22	0.03	0.018
KS	DRY SS	5/28	10/20	SOYBEAN[4]	4.2	116	2705	7986	2286	32	0.16	0.10	2.5	0.95	54	77	22	0.03	0.018
DE	DRY	6/01	10/31	SOYBEAN[4]	4.2	116	2705	11000	3600	32	0.16	0.10	3.8	0.95	54	77	22	0.03	0.018
DE	DRY	5/23	11/03	SOYBEAN[5]	3.7	116	2832	8262	2430	32	0.16	0.10	2.7	0.95	54	77	22	0.05	0.018
DE	DOUBLE-CROP	7/20	12/09	SOYBEAN[3]	4.2	110	2600	5140	1800	20	0.16	0.10	2.0	0.75	54	77	22	0.03	0.018
IN		5/28	10/20	SOYBEAN[2]	4.8	121	2238	11400	3300	36	0.16	0.10	4.0	0.95	54	77	22	0.03	0.018
IA		5/17	10/17	SOYBEAN[2]	4.8	76	2238	11400	3300	36	0.16	0.10	4.0	0.95	54	77	22	0.03	0.018
GA		5/5	10/30	SOYBEAN[7]	4.8	92	3230	14400	4500	36	0.16	0.10	4.2	0.95	54	77	22	0.03	0.018
ND	DRY	4/21	9/05	SWHEAT	4.3	86	2350	9836	3600	42	0.16	0.10	2.5	0.90	40	78	40	0.08	0.0234
KS	DRY	9/20	6/21	WWHEAT	4.3	176	1500	9836	3600	42	0.16	0.10	2.5	0.90	45	82	80	0.10	0.0234
KS	IRR	9/22	7/05	WBARLEY	4.3	197	2000	16800	6000	42	0.16	0.10	3.1	0.85	42	75	47	0.28	0.0234
KS	FALLOWED	9/22	7/05	WBARLEY	4.3	197	2000	16701	5982	42	0.16	0.10	3.1	0.85	42	75	43	0.28	0.0234
KS	IRR	4/21	7/22	SBARLEY	5.2	116	1915	9670	2900	38	0.16	0.10	2.7	0.99	42	75	30	0.32	0.0234
KS	DRY	4/21	7/22	SBARLEY	4.6	116	1915	8354	2210	38	0.16	0.10	2.1	0.99	42	75	30	0.32	0.0234
KS	IRR	4/11	7/22	OATS	5.5	128	2176	11700	3520	42	0.16	0.10	3.5	0.98	40	77	40	0.28	0.0234
KS	DRY	4/11	7/22	OATS	5.2	128	2176	9075	2395	42	0.16	0.10	3.0	0.98	40	77	40	0.28	0.0234
MN	DRY	4/25	8/05	OATS	5.3	128	2090	9060	2327	42	0.16	0.10	3.5	0.95	40	77	35	0.28	0.0234
KS	IRR MEDIUM	5/21	9/30	GSORGHUM	5.0	120	2185	19760	8695	36	0.16	0.10	2.9	0.95	54	95	55	0.05	0.0200
KS	DRY	5/21	9/30	GSORGHUM	4.6	120	2185	14122	5633	36	0.16	0.10	2.3	0.95	54	95	55	0.05	0.0200
KS	IRR M EARLY	5/20	9/27	GSORGHUM	4.8	120	1875	17490	7696	36	0.16	0.10	2.9	0.95	54	95	55	0.05	0.0200
KS	DRY M EARLY	5/27	9/27	GSORGHUM	4.8	120	1875	17490	7696	36	0.16	0.10	3.1	0.85	54	95	55	0.05	0.0200
DE	DRY EARLY	5/23	10/20	GSORGHUM	4.8	102	1875	12850	4750	36	0.16	0.10	3.6	0.85	52	92	50	0.02	0.0200
DE	DRY LONG	5/23	11/15	GSORGHUM	4.8	102	2480	14000	5600	38	0.16	0.10	3.9	0.85	52	92	50	0.02	0.0200

PD = plant date, HD = harvest date, SS = short season, LS = long season, DRY = dryland, IRR = irrigated.
Soybean superscripts indicate maturity rating; higher numbers indicate longer growing season.

DDEM(J) (a) Measure of age in degree-days [°C-days or °F-days] between planting and emergence of plant J. (b) If plant is a perennial, DDEM represents the degree-day interval between beginning of year (or July 1 in Southern Hemisphere) and plant emergence. Degree-days are calculated as the temperature difference between daily mean air temperature and crop base temperature, TGBM (defined below).

DDMX(J) Degree-day measure from planting of crop J to its maturity, when growth ceases and senescence begins [°C-days or °F-days]. Figure 5 illustrates F_s, the age factor used in determining crop-growth rate. As DDMX is approached, the growth rate drops sharply.

For perennials, DDMX is counted from January 1 (July 1 in Southern Hemisphere); for annuals, degree-day accumulation starts at planting. For example, DDMX for corn is reached well before harvest. By contrast, for a hay or silage crop, one or more harvests may have occurred before this age.

PDRYM(J) Potential (optimum) total dry matter for crop J [kg/ha or lb/ac]. Figure 6 indicates how the crop-growth-rate/size factor F_m drops as the crop dry matter approaches this potential.

POTY(J) Potential yield of fruit and seed of crop J [kg/ha or lb/ac]. It is not the same as the harvested weight when "harvest" may include part of plant leaves and stems.

RDP(J) Potential maximum root depth for plant J [mm or in]. Specification of this variable should consider the effect of any restrictive soil horizons. It must also fall within the given soil profile (i.e., it must be less than or equal to depth of bottom of deepest soil horizon, GZ(NSL) on the last C02 data line).

PLIG(J) Aboveground lignin content of plant J, expressed as a fraction of dry matter. Values are listed for various plants in table 8.

RLIG(J) Below-ground lignin content of plant J; expressed as a fraction of total dry matter. Values for this parameter are also given in table 8. This fraction is typically about half of PLIG.

Table 8.
Typical aboveground lignin contents for selected plant materials

Plant or crop	Aboveground lignin content weight fraction
Bluegrass	0.053
Oats	0.049
Early millet	0.063
Soybeans	0.097
Lespedeza	0.142
Intermediate millet	0.11
Oak (leaves)	0.22
Wheat	0.164
Corn stover	0.15

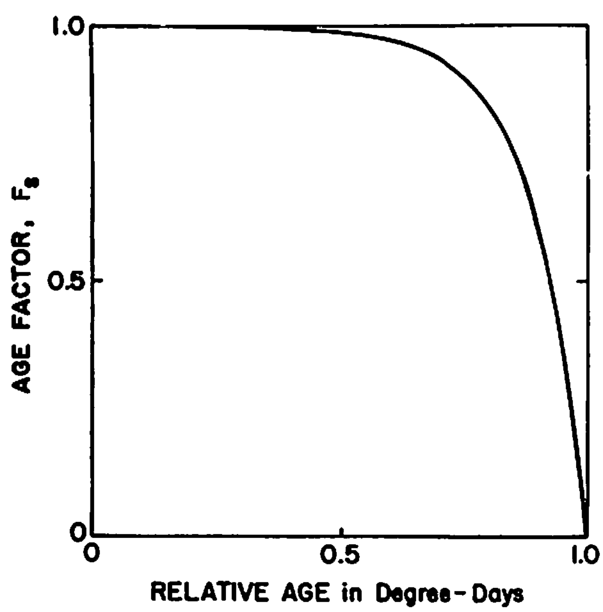

Figure 5. Crop age factor, which causes growth shutdown as maturity is reached.

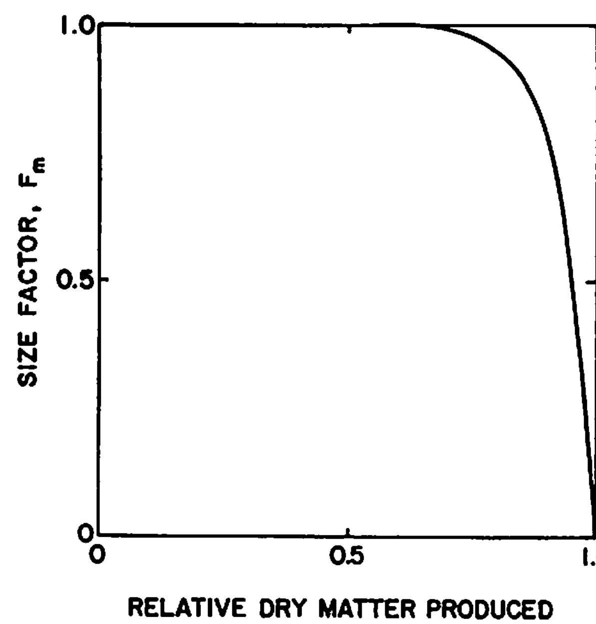

Figure 6. Crop size factor, which causes plant growth shutdown as full potential size is reached.

D03: POTHT(J), PPCV(J), TGBM(J), TGOP(J), CONVF(J), DEACT(J), COVI(J), DMINIT(J)

POTHT(J) Potential total plant height for plant J [m or ft].

PPCV(J) Relative amount of ground surface covered by projected area of crop J when mature. For a thick stand of corn or grass, PPCV is near 1.0. For peanuts, PPCV is much smaller, depending on planting density. This parameter is distinguished from and complementary to PLAI, which refers to ratio of leaf area to plant projected area. PPCV refers in turn to proportion of total ground area taken up by projected mature plant area.

The following two growth temperature parameters determine the shape and position of the temperature-response function illustrated in figure 7:

TGBM(J) Minimum temperature for growth of plant J to occur [°F or °C]. Plant growth is very sensitive to this parameter, because it is the basis for degree-day calculations. (If a simulated crop grows too fast or too slowly, one can adjust TGBM a few degrees or adjust CONVF.)

TGOP(J) Temperature at which plant J grows at its maximum rate [°F or °C].

CONVF(J) Biomass conversion factor for plant J photosynthesis [kg/ha/ly]. This also affects basic rate of growth.

DEACT(J) Relative rate of loss of active leaf area for plant J after start of senescence. This is the fraction of remaining leaf weight lost per day [kg/kg/day or lb/lb/day].

COVI(J) For a perennial plant, indicates <u>relative shading</u> of ground in winter due to permanent plant structure such as trunk, limbs, or evergreen leaves [fraction].

DMINIT(J) Initial weight [kg/ha or lb/ac] for plant if it is planted as a seedling (e.g., tobacco or trees). If it is a seeded crop or perennial, this value is zero.

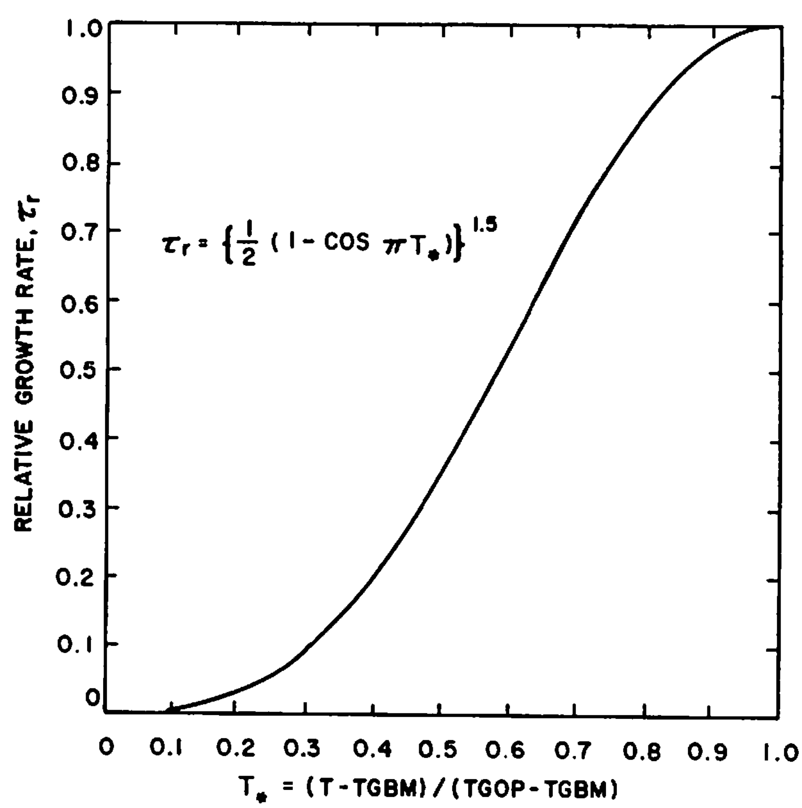

Figure 7. Crop temperature-based growth factor.

D04: CONY(J), CFXN(J), PNO(J), PNF(J), DKC(J), PNRAT(J)

CONY(J) Fractional nitrogen content of the yield (fruit and seed) of plant J [g/g or lb/lb].

CFXN(J) Flag that indicates ability of a plant to fix atmospheric nitrogen:

CFXN=0 Plant J is not an N fixer.
CFXN=1 Plant is an N fixer (there will be no N stress).

PNO(J) Nitrogen content of plant J at emergence [kg/kg or lb/lb].

PNF(J) Total nitrogen content of plant J at maximum growth [kg/kg or lb/lb].

DKC(J) Coefficient describing relative curvature of the relation of N content versus plant mass of plant J. Figure 8 illustrates how N content of a plant typically changes from PNO to PNF over its growth period. Values of DKC (C_d) range from approximately 3 for corn to 8 for soybeans. DKC can be determined with data and regression analysis.

PNRAT(J) Ratio of P to N in dry matter of plant J (assumed constant). Values of 0.2-0.375 are acceptable.

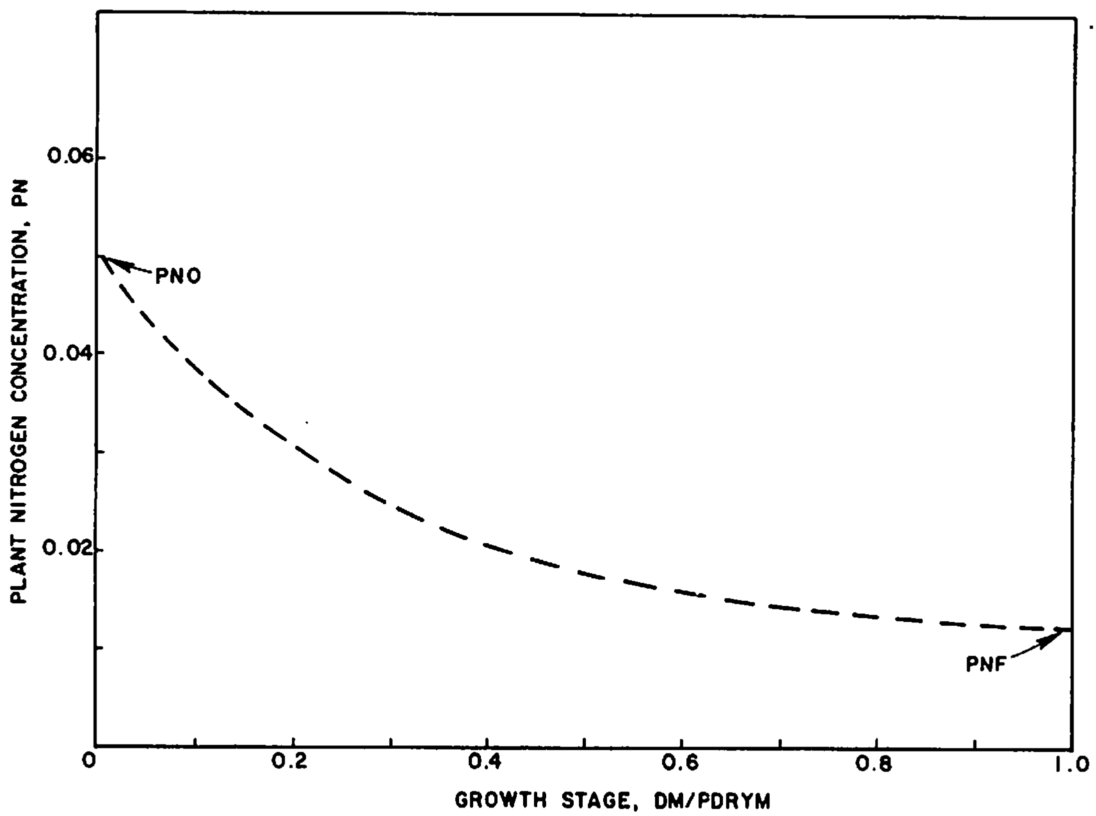

Figure 8. Plant nitrogen content as related to growth stage.

Group E. Management Data

Input group E contains

(a) descriptive parameters for all management operations performed and substances applied (E02-E09,E18), and

(b) a schedule designating target dates, during the rotation period, when the various operations are to be performed (E10-E17). The schedule includes tillage operations (including planting and harvests); applications of pesticides, fertilizers, and manure; and irrigation. Most of these dates are subject to delay if the field is wet. The criterion for this is THEMTH, described below.

E01: THEMTH — Relative water content in the upper soil above which no field operations are undertaken [mm/mm or in/in]. Large value (e.g., 0.99) avoids delays in schedule. Relative water content is scaled between saturation and residual water content (saturation = 1.0, residual = 0.0).

Tillage Operations Description

The tillage operations are described on lines E02-E03. Five general categories or operation types (NTYTL) can be simulated, as described below.

Any particular tillage operation should fall into one of these categories. A particular operation is specified by a seven-character name, a mixing depth and efficiency, a resultant random roughness, and the resultant furrow geometry. Table 9 gives estimated values of efficiency and random roughness for a variety of tillage operations. For harvests (NTYTL=3 or 5), the efficiency value represents the relative amount of plant material removed. If the value is set to zero, only yield (seed and fruit) is removed.

A harvest (NTYTL=3) operation when the crop is perennial pasture or meadow (IPER=2 or 4) signals grazing. In this case, the relative-roughness value RFT is reinterpreted to be the length (days) of the grazing period, and the depth-of-mixing parameter PLOWD is reinterpreted as the daily rate of grazing (kg/ha or lb/ac).

When plowing (NTYTL=4) is specified with PLOWD=0.0, a chopping operation is assumed, in which standing plant material is added to surface residue only, with no soil mixing.

Lines E02-E03 contain the number of different tillage operations to be simulated and a physical description of each type.

E02: NTL — Number of different tillage operations used over total rotation cycle; cannot exceed 20.

Table 9.
Suggested values of variables for selected tillage operations

Tool used in tillage operation	Operation type NTYTL	Random roughness (mm) RFT & RGSURF	Mix/harvest efficiency EDTL
Large offset desk	4	50.	0.60
Moldboard plow	4	30.	0.90
Lister	4	25.	0.80
Chisel plow	4	20.	0.33
Disk harrow	4	18.	0.50
Field cultivator	2	15.	0.30
Row cultivator	2	15.	0.50
Anhydrous applicator	4	13.	0.15
Rod weeder	4	10.	0.05
Planter	1	10.	0.15
Smooth surface	-	6.	--

Note: There must be NTL E03 prompts and lines.

E03: IDTIL(J), IDPL(J), NTYTL(J), RFT(J), PLOWD(J), EFTL(J), DFRW(J), WFRW(J)

IDTIL(J) Seven-character alphanumeric identifying name for the operation, such as DISKHRW or ROOTPLW. IDTIL is echoed to the basic output file (created when IFOUT=2; see section "Opus Output Options") whenever the operation is performed.

IDPL(J) Index of crop, if any, associated with tillage J. This is required for planting and harvest operations. The index refers to the order of listing in the crop list lines D02 (e.g., fourth crop in the list is IDPL=4).

NTYTL(J) Integer value specifying the tillage type of operation J:

NTYTL=1 Seed-planting operation.
NTYTL=2 Cultivation operation in which any crop present is undisturbed but the soil and surface residue are mixed with a given efficiency to a given depth.

NTYTL=3 Harvest (or grazing) operation in which a given part of the plant is removed, preferentially including the yield (seed or fruit) plus optionally some part of the remaining dry matter.

NTYTL=4 Plowing or turning operation involving surface and plant material in which some portion of standing plant material is either mixed into the soil to a given depth with a given efficiency or is simply added to the surface residue.

NTYTL=5 Special harvesting/plowing operation to bring roots and plant to surface and (optionally) to remove root crops (e.g., onions, potatoes, and peanuts). Does not affect standing dry matter, as does a type-4 tillage.

RFT(J) (a) Random roughness on field produced by operation J [mm or in], up to about 50 mm for very deep disking. Value of surface roughness at simulation start is read as RGSURF on line B02. Example values are given in table 9.
(b) As explained above, for harvest type under grazing perennials, this parameter is reinterpreted as representing the number of days in the grazing rotation.

PLOWD(J) (a) Depth of mechanical mixing for operation J [mm or in]. PLOWD is limited to depth of top horizon, because no reasonable way exists to predict the result on physical characteristics of horizon mixing. PLOWD<10mm indicates chopping of standing material, which is added to surface residue layer.
(b) As indicated above, only for harvest operations on grazed perennials (NTYTL=3 <u>and</u> IPER=2 or 4), this parameter is interpreted as daily grazing rate [kg/ha/day or lb/ac/day].

EFTL(J) Mixing efficiency within the mixing depth for operation J. For crop harvesting (NTYTL=3 or 5), this parameter is interpreted as harvest efficiency, the relative amount of plant material removed. In this case, if EFTL=0, only the yield (fruit and seed) is removed.

DFRW(J) Depth of furrows produced by operation J [cm or in]. When negative, no change in existing furrow depth is assumed to be caused by the operation. When positive, it specifies depth of furrows created at time of cultivation.

WFRW(J) Width of furrow produced by mechanical operation J [m or ft]. Together with DFRW(J), it describes furrow-flow geometry before any erosion alters the shape. This value must not change for operations between planting and harvesting of row crops.

Pesticide/Radionuclide Descriptions

Lines E04 through E07 list parameters of pesticides and radionuclides (if any) applied, if IFPEST (line A03) is >0; if IFPEST=0, data on these lines are ignored. Table 10 includes many of the data called for in the following lines, for a variety of currently available pesticides. Line E07 describes the initial pesticide/radionuclide distribution in the soil.

E04: NPST Number of different pesticides or radionuclides (either but not both) to be either traced or applied during simulation period. There must be NPST sets of prompts and data lines E05 through E07.

E05: IDPST(K), DKFL(K), DKSOIL(K), DKOC(K), PPWLF(K), PINSLT(K), PSOLUB(K), FWASH(K), BEXTR(K), RELP(K)

IDPST(K) Alphanumeric identifying name for pesticide K (up to seven characters).

DKFL(K) Foliar decay coefficient for pesticide K. Decay is represented by exp(-DKFL*time) and is related to foliar half-life as DKFL = 0.693/(half-life) [1/day].

DKSOIL(K) Decay coefficient for decay of pesticide K in the soil. The decay expression and units are same as those for DKFL. See volume I for a description of how environmental factors (temperature and moisture content) change the decay rate. Related parameters are found on E06.

Table 10.
Parameter estimates for commonly used pesticides

Common name	Trade name	PSOLUB (ppm)	DKFL	DKSOIL	K_d[1] (ml/g)	QPEST[2] (kg/ha)
Acephate	Orthene	650000.0	0.087	0.35	3.0	1.12-4.48
Alachlor	Lasso	242.0	0.231	0.0384	5.0	2.24-4.48
Atrazine	Atrazine	33.0	0.347	0.01	2.9	0.56-1.68
Bentazon	Basagran	500.0	0.347	0.069	1.0	3.36-4.48
Butylate	Sutan	45.0	0.693	0.033	1.3	
Carbaryl	Sevin	40.0	0.099	0.0169	0.1	
Carbofuran	Furadan	700.0	0.630	0.04	1.3	
Chlorpyrifos	Lorsban	2.0	0.210	0.06	53.0	
Cyanazine	Bladex	165.0	0.347	0.049	5.0	
2,4-D(amine)	--	900.0	0.078	0.07	0.74	0.28-4.48
DEF	DEF	1.0	0.099	0.07	100.0	
DiCamba	Banvel	4500.0	0.075	0.084	0.077	0.07-11.2
Dicotophos	Bidrin	10000.0	0.035	0.1	0.2	
Dinitro	Dinoseb	50.0	0[3]	0.03	4.9	
EPN	EPN	0.5	0.139	0.14	200.0	
Fenvalerate	Pydrin	0.02	0.017	0.01	740.0	
Fluometuron	Cotoran	90.0	0[3]	0.06	2.0	0.56-4.48
Fonofos	Dyfonate	13.0	0.277	0.016	30.0	
Glyphosate	Roundup	12000.0	0.277	0.023	5.0	1.12-4.48
Methyl parathion	--	60.0	0.231	0.14	10.0	
Metolachlor	Dual	530.0	0.231	0.04	5.0	
Metribuzen	Sencor	1220.0	0.347	0.029	0.2	0.28-1.12
MSMA	MSMA	570000.0	0[3]	0.07	4000.0	2.24-4.26
Paraquat	Paraquat	500000.0	0.231	0.007	100000.0	0.28-1.12
Permethrin	Pounce	0.5	0.020	0.015	1000.0	
Phorate	Thimet	50.0	0.347	0.03	9.4	
Profluralin	Tolban	0.1	0.693	0.005	22.4	0.56-1.68
Propachlor	Ramrod	580.0	0.231	0.058	5.0	3.36-6.72
Propazine	Milogard	8.5	0.347	0.008	2.1	1.12-4.48
Simazine	Princep	3.5	0.347	0.01	2.3	2.24-4.48
Sulprofos	Bolstar	45.0	1.386	0.05	5.5	
Terbufos	Counter	15.0	0.277	0.139	30.0	
Trifluralin	Treflan	1.0	0.035	0.01	19.2	0.56-2.24

[1]KOC is K_d divided by organic carbon content of the soil (usually use top layer or an average of several top layers, if shallow): DKOC = K_d/(ORGC(1)/100).

[2]Range for active ingredient. Values are examples of amounts used in tests, not recommended application amounts (USDA 1980, pp. 549-554; USDA-SCS 1984, p. D-2).

[3]Preemergence herbicides and directed herbicidal sprays do not get on crop foliage, so a foliage residue half-life for these chemicals is 0.0.

DKOC(K)	Equilibrium adsorption coefficient for pesticide K [mL/g; English units not used], which is multiplied by carbon content (fraction by weight) to obtain the estimated isotherm adsorption coefficient (k_d) for soil adsorption ratio of pesticide K. Table 10 lists k_d values for commonly used pesticides. To calculate DKOC, divide these values by the organic carbon fraction of the topsoil (ORGC(1)/100). For a radionuclide (whose adsorption is not dependent on organic carbon as are pesticides), the value read in as DKOC is used directly as k_d.
PPWLF(K)	Amount of pesticide K initially on plant surfaces [kg/ha or lb/ac].
PINSLT(K)	Initial concentration of pesticide K that is in the top 10-mm surface region of the soil [mg/kg of soil, or ppm]. There are two ways to assign initial soil pesticide profile values, depending on whether the user knows the depth distribution of residual pesticides. If only surface PINSLT is known or estimated, Opus initializes the remaining root zone by distributing decreasing amounts in lower layers. USE THIS METHOD ONLY WHEN ACTUAL INITIAL CONCENTRATIONS ARE NOT KNOWN. For this approximation, line E07 is left blank. Otherwise, assign concentration-depth values on line E07 and leave PINSLT blank.
PSOLUB(K)	Water solubility of pesticide K [g/t or ppm].
FWASH(K)	Plant-washable portion of pesticide K. It is a value from 0.0 to 1.0, indicating the portion of pesticide on the plant surface that is subject to being washed off by rain (or sprinkle irrigation).
BEXTR(K)	Surface flow extraction coefficient for pesticide K, expressing the net action of various factors that determine pesticide pickup by surface runoff [kg/L].
RELP(K)	Rate factor for the kinetic adsorption model [min^{-1}]. This parameter is used as a flag to turn on the kinetic adsorption option: Values greater than or equal to 0.01 are comparatively large and result in default use of the equilibrium model. Also, if given as 0. or less, default=0.9 is used (equilibrium adsorption).

E06: DKTHE(K), DKTEMP(K), ARRHC(K)

Line E06 contains information about the pesticide degradation factor DKSOIL, as follows:

DKTHE(K) Relative soil moisture content at which the given DKSOIL(K) [line E05] was determined, if known [mm^3/mm^3 or in^3/in^3]. Varies between 0.0 at 15-bar tension to 1.0 at saturation. Default = 0.5.

DKTEMP(K) Temperature at which DKSOIL (E05) was determined, if known [°C or °F]. Default = 21°C.

ARRHC(K) Arrhenius equation activation energy for degradation effects on pesticide K [Kcal/mole]. Default = 10.0.

E07: PLCON(I,K), PLDEP(I,K), I=1,10

Line E07 contains pairs of concentration-depth data that describe initial residual pesticide K in the soil. Values are entered 5 pairs per line, with a maximum of 10 pairs (2 lines). The values of PLDEP need not correspond to input soil horizons, because they rarely do in available data. Opus assigns depth-weighted average values to its computational layering scheme. When the maximum PLDEP depth is less than the deepest soil horizon, the last value PLCON is extended to the lower boundary of the current computational layer, and initial pesticide in each successive layer is initialized to 1% of the value of the previous layer.

PLCON(I,K) Initial concentration of pesticide K in soil beween depth PLDEP(I-1,K) and depth PLDEP(I,K) [mg/kg of soil, or ppm].

PLDEP(I,K) Depth (from the surface) to the bottom of region where PLCON(I,K) applies [mm or in].

Manures

Lines E08 and E09 list information about any user-defined manures to be applied as a management operation. Nine manure types (typing based on composition) are contained in an Opus internal database (listed in table 11). If the parameter NMAN on line E08 is zero, the user must use only database-supplied manures.

E08: NMAN Number of manure types for which characteristics are to be read on line E09. Must be ≤ 10.

Table 11.
Properties of manure types included in Opus

Source	N	ATN(N) (%)	ANH(N) (%)	APHOS(N) (%)	AOM(N) (%)
Beef, solid	1	2.10	0.36	0.80	52.0
Dairy, liquid	2	0.115	0.10	0.005	0.10
Dairy, solid	3	2.00	0.48	0.60	18.0
Horse, solid	4	1.10	0.0	0.20	21.0
Domestic sludge	5	5.20	0.21	2.50	30.0
Poultry, solid	6	5.00	0.0	1.80	75.0
Sheep, solid	7	4.00	0.0	0.60	28.0
Swine, solid	8	0.141	0.13	0.005	1.0
Swine, liquid	9	2.80	0.0	0.60	18.0
(Reserved for user-definition)	10	--	--	--	--

Line E09 and its prompt are repeated NMAN times.

E09: N, ATN(N), ANH(N), APHOS(N), AOM(N)

N — Identifying index of manure type being read. If less than 10, replaces the database type number N. Cannot be >10.

ATN(N) — Total nitrogen content of manure type N [%].

ANH(N) — Ammonia content of manure type N [%].

APHOS(N) — Phosphorus content of manure type N [%].

AOM(N) — Organic matter content of manure type N [%].

Management Schedule Information

Lines E10-E17 describe the schedules of tillage, fertilizer applications, and pesticide applications. These data refer to the timing of operations, conpared with their basic parameters, which were given in the previous data lines E02-E09.

E10: NYROT — Number of years in rotation cycle. Maximum value is 5.

Lines E11-E17 are a set repeated for each year [Y = 1 to NYROT] in the rotation sequence. There must be NYROT sets of E11-E17 prompts and lines.

E11: NTY — Number of tillage operations during rotation year Y.

E12: MO, IDA, KTILL

There must be NTY pairs of E12 prompts and lines. Line E12 contains the chronological tillage schedule:

MO — Month of the operation.

IDA — Day of month of tillage.

KTILL — Identifier of particular tillage operation, corresponding to rank in tillage list read in lines E05 (e.g., fourth tillage operation in the list is KTILL=4).

Lines E13-E14 are included for each year in the rotation cycle but are used only if the nutrient option flag IFNUT is nonzero. This set describes the number and schedule of the year's fertilization and/or animal-waste-application operations. Applications must be in chronological order.

E13: NFR(Y) — Year's total number of nutrient or waste applications (up to 10); indicates number of E14 prompt and line pairs to follow.

E14: MO, IDA, KAPPL(Y,J), FERN(Y,J), FERP(Y,J), FERA(Y,J), MATYP(Y,J), RATE(Y,J), DEPIN(Y,J)

There must be NFR E14 prompt and line pairs. Applications must be listed in chronological order.

MO — Month of application J.

IDA — Day of month of application J.

KAPPL(Y,J) — Method code for the J^{th} nutrient application in rotation year Y. Application methods are:

KAPPL=0 Surface-applied.
KAPPL=1 Injected.
KAPPL=2 Dissolved in irrigation water.

FERN(Y,J) — Amount of fertilizer NO_3-N applied in application J [kg/ha or lb/ac].

FERP(Y,J) Amount of fertilizer PO_4-P applied in application J [kg/ha or lb/ac].

FERA(Y,J) Amount of fertilizer NH_4-N applied in application J [kg/ha or lb/ac].

MATYP(Y,J) Manure applied in the J^{th} application in rotation year Y. This is zero for application of a fertilizer (and not manure). For manure applications, NMAN must be >0 and this parameter takes values from 1 to 10, corresponding to the identifying index of default manure type or the index of data read on line E09.

RATE(Y,J) Application rate or loading of manure, if any in the J^{th} application in rotation year Y. For solid or sludge material, RATE is given in tonnes/ha or tons/ac. For liquid application, units are for volume per unit area [mm or in].

DEPIN(Y,J) Depth of injection of manure or fertilizer, if injected (KAPPL=1), in the J^{th} operation [mm or in].

Lines E15-E16 are included for each year in the rotation cycle but are used only if the pesticide option flag IFPEST is nonzero. This set describes the number and schedule of the year's pesticide application operations, which must be in chronological order.

E15: NPEST(Y) Number of pesticide applications in rotation year Y. Limit is 15 applications per year for each of the (up to 5) rotation years.

E16: MO, IDA, KPEST(Y,J), IAPLIC(Y,J), QPEST(Y,J), FRACA(Y,J), FRACP(Y,J), DEPST(Y,J)

There must be NPS E16 prompts and lines. This data line includes specification of the pesticide amount and the application method. If enough is known about the particular method of application, the user may specify the resulting distribution of pesticide, in terms of fraction of total application that appears on soil and on plants or that is lost into air. Figure 9 illustrates this division and the data names for each.

MO Month of application J.

IDA Day of month of application J.

KPEST(Y,J) Type of pesticide used in the J^{th} application, corresponding to order of list on lines E06-E07 (e.g., fourth pesticide read is KPEST=4).

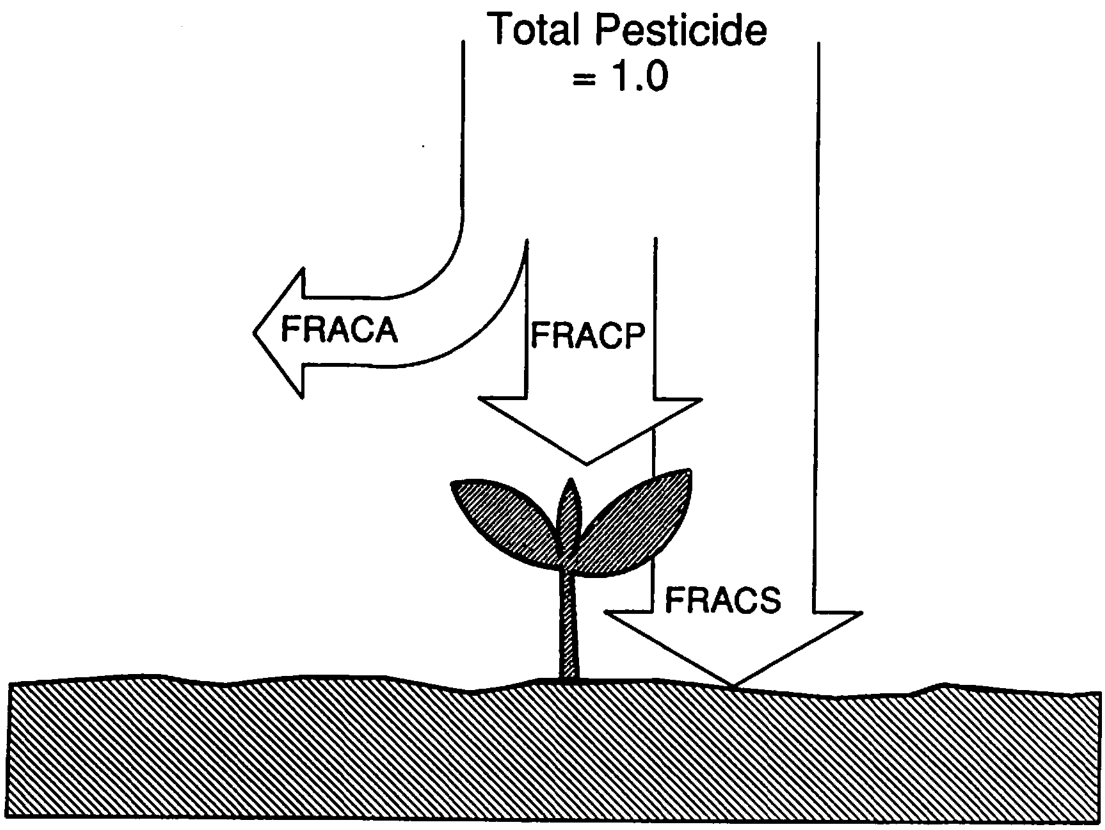

Figure 9. Scheme of possible fractions of total pesticide applied. Amount of each fraction depends on application method.

IAPLIC(Y,J) Code indicating method of application of pesticide J:

IAPLIC=0	Soil injection.
IAPLIC=1	Spray application, with specified division between proportion landing on soil and that landing on plant surfaces.
IAPLIC=2	Application in irrigation water.
IAPLIC=3	Aerial application as in 1, but the program, on the basis of current aboveground plant mass, calculates the relative amounts landing on plant and soil surfaces.

QPEST(Y,J) Amount of pesticide applied in the J^{th} application [kg/ha or lb/ac].

FRACA(Y,J) Fraction of applied amount of pesticide K that is lost in application. This is near zero for soil-incorporated pesticides but is much larger for aerial application.

FRACP(Y,J) Fraction of applied pesticide K that reaches plant surfaces (the division is illustrated in fig. 9). This value is close to zero for pre-emergent herbicides. FRACP plus FRACA equals 1.0-FRACS, where FRACS is the fraction of applied pesticide that reaches the soil surface. When IAPLIC(K), defined above, is 3, the program calculates FRACS and FRACP from the given value of FRACA and the current amount of plant material on the field.

DEPST(Y,J) Depth of pesticide injection [mm or in], if IAPLIC is zero.

E17: IRRDY, MO, IDA, NIRD, AMIRR, TIRR, THIRR, QIRR

Line E17 specifies the irrigation schedule, if any, for rotation year Y.

IRRDY(Y) Number of days in irrigation season, for ditch supply-type irrigation.

MO(Y) Month in which irrigation season begins.

IDA(Y) Day of month on which irrigation season begins.

NIRD(Y) Interval of days between irrigation opportunities for regulated ditch supply irrigation (IFIRR=3).

AMIRR(Y) Maximum depth of irrigation per event [mm or in].

TIRR(Y) Total annual irrigation supply [mm or in] (IFIRR=3).

THIRR User-selected threshold water content of near-surface soil, below which irrigation will be performed in a demand-type schedule system (IFIRR=1 or 2) [mm/mm or in/in]. THIRR is scaled between residual and saturated water content, so it takes values from 0 to 1.

QIRR — Rate of application to the whole field area [m^3/s or ft^3/s]. This information is used with AMIRR to determine length of irrigation period.

Draintiles

E18: DRSP, DDIMP, RCLM

Line E18 specifies position of draintiles and subsurface leakage rates when use of draintiles is simulated (IFDRAN≥1). The line may be blank when IFDRAN=0. These parameters cannot be changed between years.

DRSP — Mean drainage spacing [m or ft].

DDIMP — Depth below drains to a restrictive or impervious boundary [m or ft]. If a value is unknown, use a large number, not zero (there is no internal default).

RCLM — Mean rate of seepage through restrictive boundary at depth DDIMP [mm/hr or in/hr]. This can be zero but not negative.

Group F. Hydrologic Field Dimensions

Group F describes the dimensions and slope shape of the catchment as interpreted for hydrologic purposes. The actual topographic shape must be interpreted in terms of a hydrologically representative set of rectangular fields and receiving channels. The mean-path-slope pattern may be described in some detail (as illustrated below) whereas a natural-catchment-plan shape must be interpreted to a variable extent into geometrically simpler units.

The general interpretation of an elementary catchment is illustrated in figure 10. The transformation or mapping of the actual catchment shape into the geometrical hydrologic equivalent is partly subjective, but the resulting abstraction should preserve the following features:

(a) catchment area
(b) mean surface (or overland) flow-path length
(c) net slope of mean flow path
(d) concentrated (or channel) flow-path length.

Figure 10 shows the method for accomplishing such representation in one example. Points on the natural topography at the top of the figure have been mapped to hydrologically similar points on

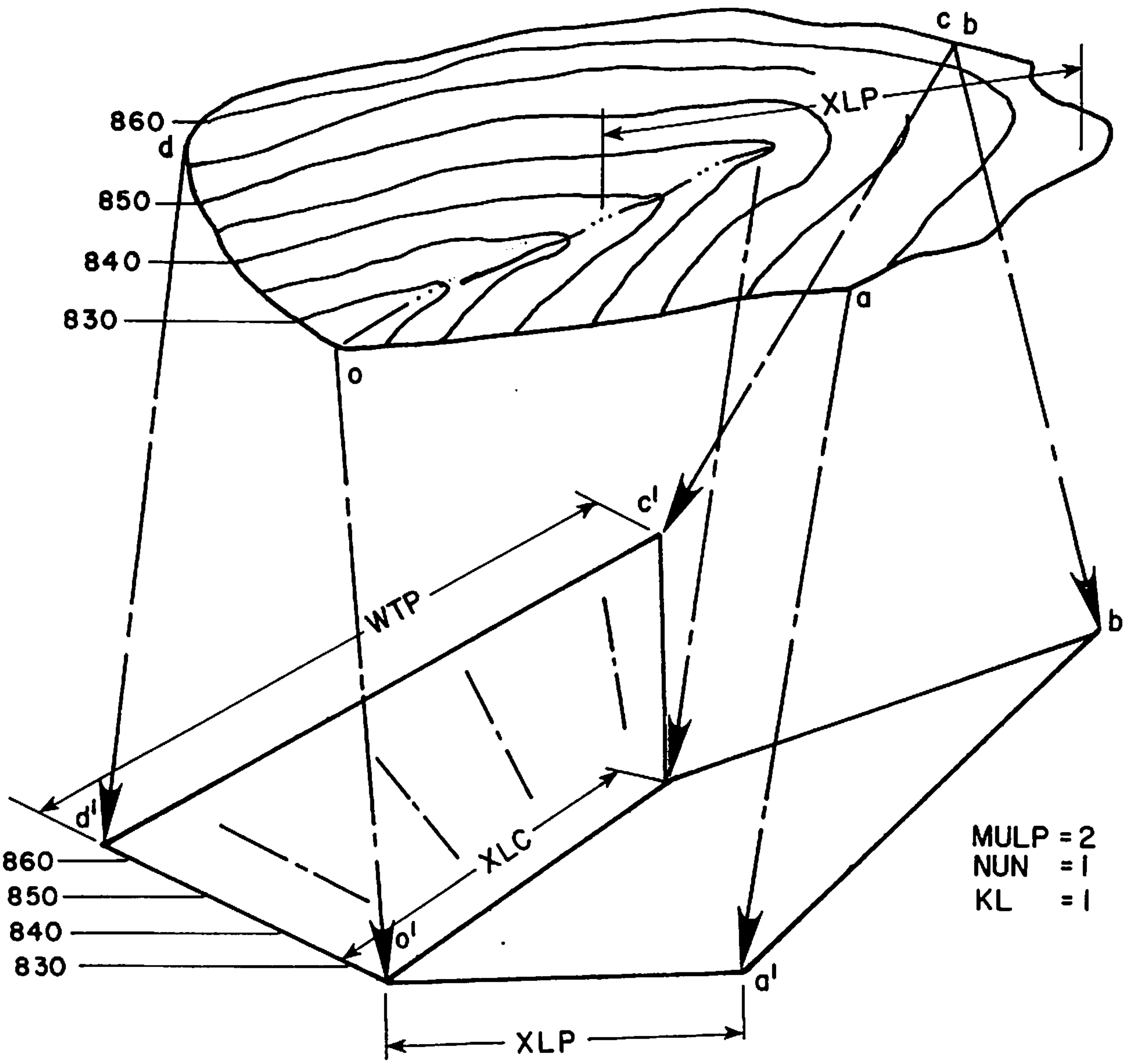

Figure 10. Elementary catchment simplification, showing interpretation of a contour map into a geometrically simpler hydrologic equivalent.

the interpreted catchment below. Area, mean flow-path lengths, and net slopes have been preserved. Note that convergence of the overland flow is also preserved by matching the width of flow at the catchment divide with a similar dimension in the geometrical representation. This divide length, or upper flow width, is shown as parameter WTP. XLP is the mean field or surface-flow-path length, and XLC is the channel or concentrated-flow-path length. As can be seen in figure 10, if WTP is greater than XLC, the flow is convergent.

Opus constrains the unit-catchment topology to have either (a) a single, plane surface contributing to one side of a receiving channel or (b) identical planes contributing to both sides of a receiving channel. The total field may, however, be made up of several such unit catchments (as in a terrace system) that contribute to a second channel.

The shallow-flow part of the field is not necessarily a plane surface. For example, it may be made up of parallel microchannels like those in a furrowed field. The shallow-flow part may also be a large, relatively featureless surface like that on a natural catchment. The changes in slope along the flow path may be described in some detail. Figure 11 illustrates how local slope should be described by an array of data pairs, consisting of a local slope and the distance from the top of the field or catchment divide to the given location. Since the model interpolates between successive points with a smoothly changing slope, it is not necessary or useful to specify slopes between end points of any reach in which the slope changes smoothly, especially where the profile is similar to an arc. The user can best describe a complicated slope profile by keeping in mind that Opus will fit arcs between each specified point, each tangent to the specified slope at the end points where the arcs join.

Opus allows the user to construct the total field hydraulic geometry with multiples of a simple unit. As indicated above, the basic unit may be either a one-sided element (MULP=1) or a two-sided element (MULP=2) (such as in fig. 10). This feature allows the description of more complex field shapes, such as fields with divided flow, and particularly terrace systems (as illustrated below). The number of units aggregated is termed NUN.

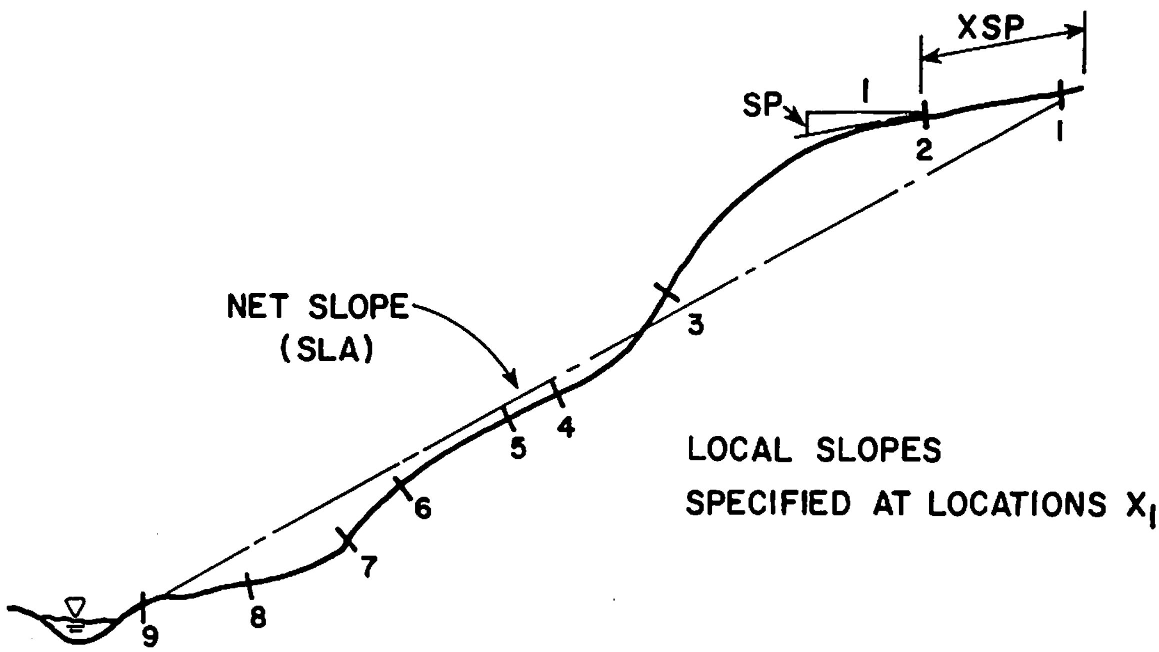

Figure 11. Definition diagram for specifying local slopes.

Opus recognizes that tillage and resultant furrows can significantly affect the actual hydrologic geometry of an area. Thus, hydrologic geometry data may be read for both the natural, untilled flow paths and the furrowed flow paths for a given field. This requires the input of two sets of hydrologic topography information. Set 1 is the untilled case, for unfurrowed flow, coded KL=1. Set 2 is the tilled case, for the furrow flow paths, coded KL=2. For simulation of untilled or natural catchments (NTY=0 on E11), only the first (KL=1) case needs to be read.

Figures 12 and 13 exemplify the two geometries that describe alternate flow paths for an example field. In figure 12, flow follows the natural shape, flowing perpendicularly to the contours and thus converging toward the outlet (pictured as a small impoundment). The value of WTP is computed within the program to preserve the field area, using flow length and the length of the intercepting channel, XLC. Mean flow path XLP(1) is assumed measured (input). Thus, total field area (here with a negligible XLC) will be = 0.5*(XLP(1))*(WTP(1)+XLC(1)). The parenthetical 1 refers to unfurrowed (KL=1) geometry.

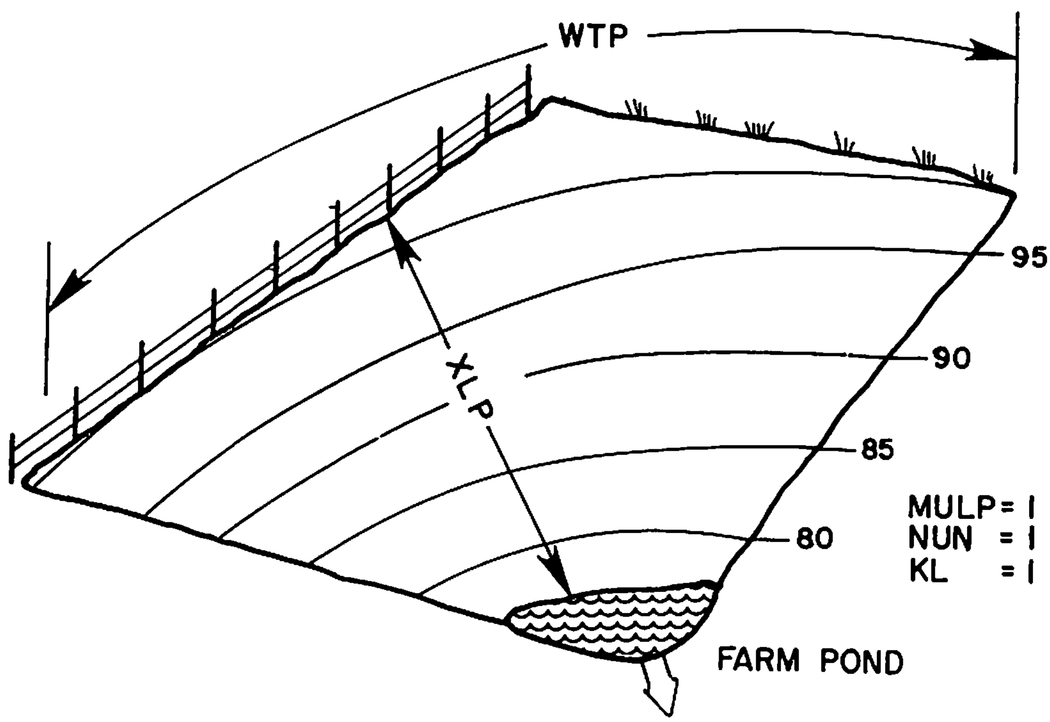

Figure 12. Untilled field example, with flow perpendicular to contours, converging to small pond.

If the same field is tilled as shown in figure 13, furrows will cause runoff to flow along the left-to-right furrow "channels." Convergence cannot occur in furrowed (KL=2) conditions unless the overtopping negates the furrow control. In the furrowed condition, the total flow path is lengthened and the slope profile is flattened and changed, but the total elevation change from top to bottom should be preserved. Mathematically

XLP(1)*SPL(1) + XLC(1)*SC(1) = XLP(2)*SPL(2) + XLC(2)*SC(2)

where SPL is net plane slope and SC is net channel slope.

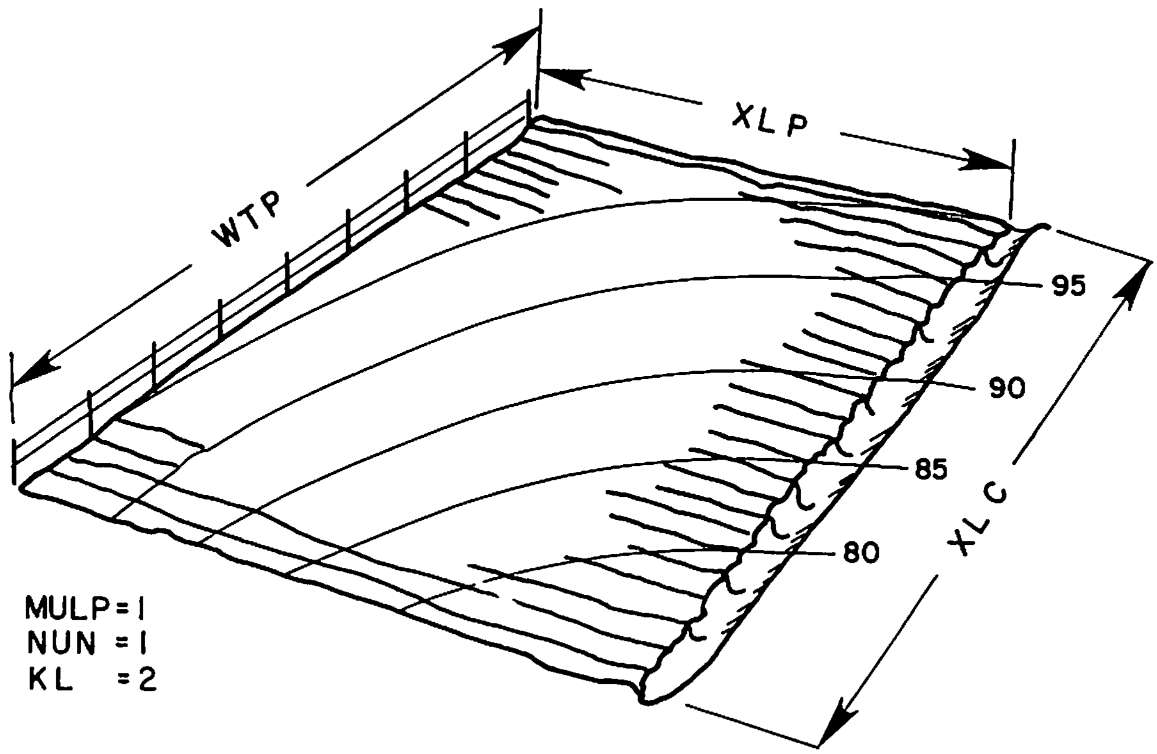

Figure 13. Topology of a tilled field.

Figure 14 gives two other examples of how simplified hydrologic geometry is obtained from natural topography. In the upper example, because water flows normal to the contours, the field's actual rectangular shape should be somewhat distorted to preserve the actual field flow-path length in the simplification. This is because the flow, as shown, is at some angle to the field border and is thus somewhat longer.

In the lower case in figure 14, flow diverges somewhat from the top of the field, because the field occupies the side of a "domed" hill. Opus is designed to accommodate convergence in its distributed-hydrology options. Divergent flow, being rather uncommon, is omitted for practical reasons. Divergent flow does not enhance erosion, for example. Thus the geometry is simulated as shown. XLP(1) is the true mean of the actual flow paths, and WTP(1) is internally adjusted to match the actual area. XLC(1) may be greater than WTP(1).

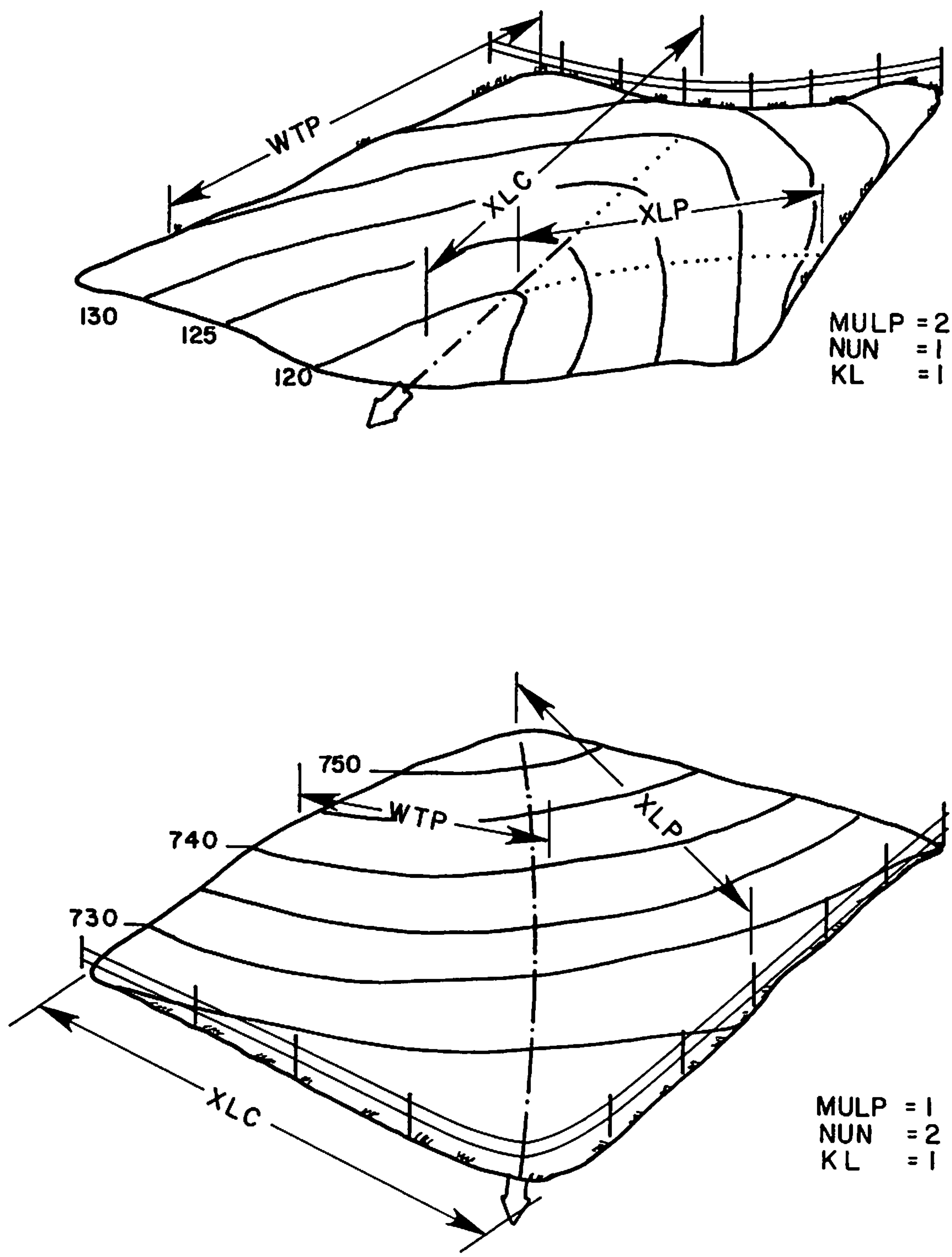

Figure 14. Two more examples of field topology, demonstrating variations in variables XLC, XLP, and WTP to describe field topography.

Figure 15 is a representation of a terrace system. In this case, flag parameter ITOCH must be set positive, and the program then expects to read extra data lines to describe the terrace outlet channel. If the individual terrace-drainage areas are not equal, perhaps because of converging flow lines, the areas should be approximated as equal, using the mean terrace-drainage area. Because it is assumed that the terrace spacing is uniform, all terraces are treated as identical.

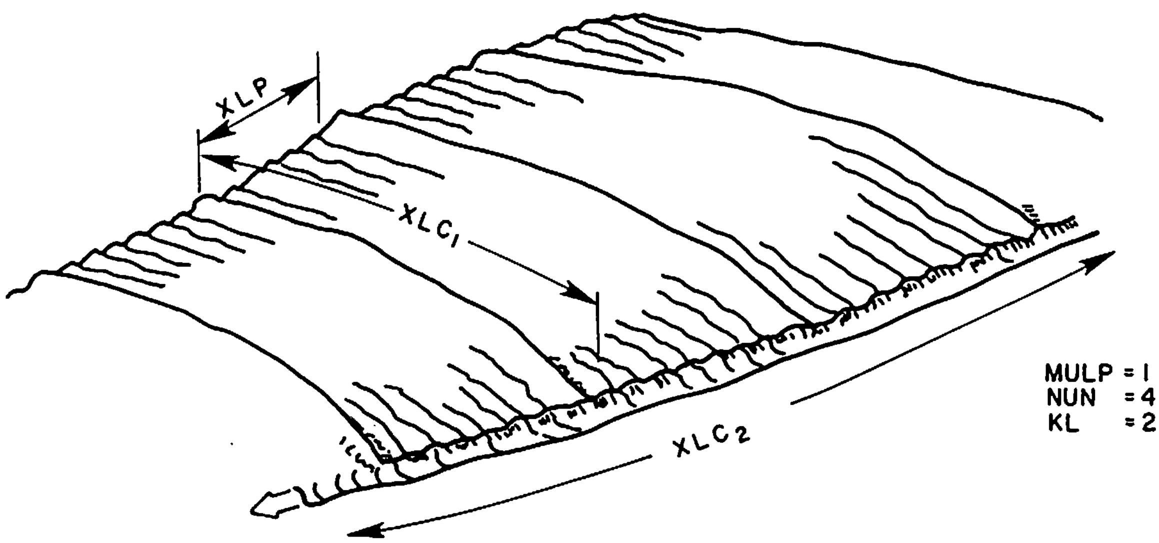

Figure 15. Example drawing of a terraced field showing basic descriptive parameters.

ITOCH is also set positive when the simulation of furrow conditions is desired at a higher order of detail. In other words, when the furrow side slopes are to be considered as short runoff planes, the furrows are treated as the channel draining the furrow side as a microwatershed. The first concentrated flow intercepting the furrow flow is treated as the second channel. This should be done only for special cases of exceptionally wide furrows (several meters).

When furrows parallel the terrace and are near zero in slope, runoff is delayed by the added storage volume in the furrows.

Contributions to the terrace channel (XLC(2)) conceptually occur only after furrow storage is exhausted and flow is effectively perpendicular to the furrows. In Opus, this is simulated in just this manner. Thus, although furrows are parallel with the channels in this case, and XLP(2) should be measured along the terrace, the program will select XLP(1) when furrow slope is sufficiently small, and furrow storage will be part of the runoff simulation. The upper slope limit for this case is 0.001.

Figure 16 exemplifies an abstracted catchment of relatively complex geometry. PAR is the area of an elementary unit, here composed of a pair (MULP=2) of planes with a central channel and a small upstream area ARUP(1). There are four such units (NUN=4) in the total catchment, plus an area at the head of the central channel, ARUP(3). The central channel is a second-order channel, so it is element number 3, and the upper area is termed ARUP(3). The total catchment area is ARUP(3) + 4*PAR.

Figure 17 shows the geometric simplification of a terrace system with a central outlet channel. Such an arrangement resembles the test example used in volume I, chapter 9. MULP=1 because only one plane contributes to the first channel, but there are eight such units in all: Total area = 8*PAR.

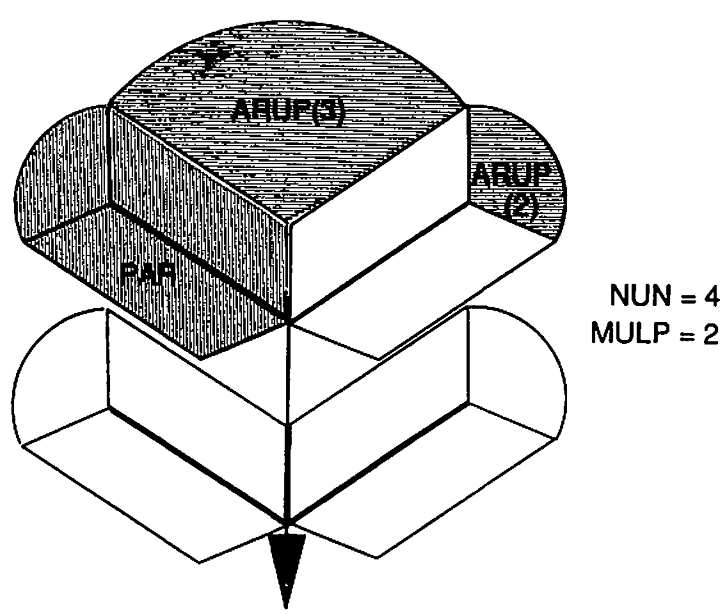

Figure 16. Example of an Opus simplification of a rather complex catchment.

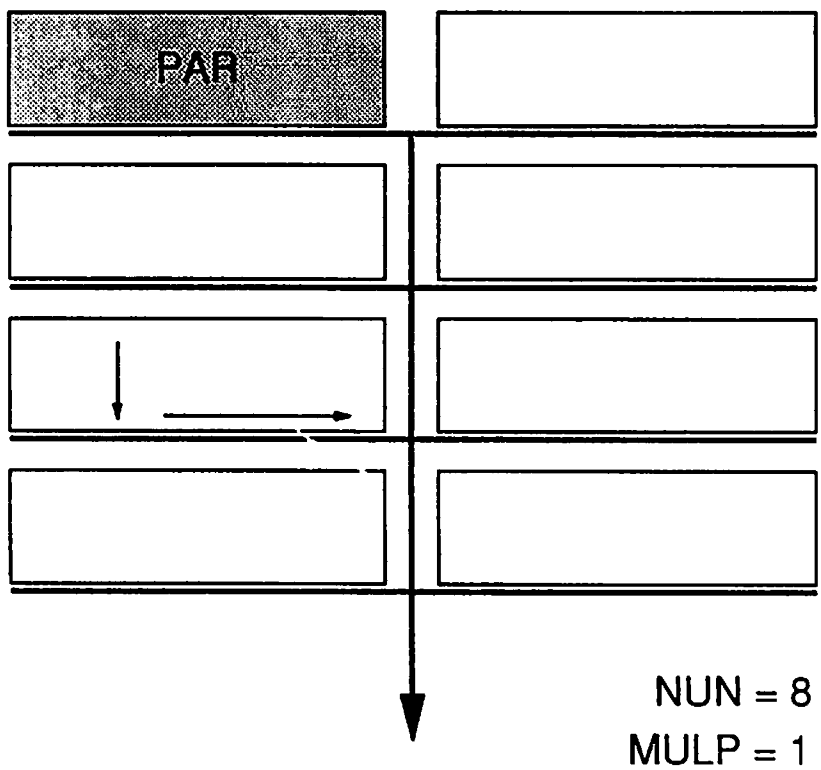

Figure 17. Simplified geometric representation of a terraced field with outlet channel, showing the Opus parameters used for its geometric features.

Another example helps to illustrate the process of geometric abstraction from actual catchments. Figure 18A shows a contour and soils map of a small 1.29-ha catchment in Georgia, near the catchment used for testing in volume I, chapter 9. There is a swale channel that is ephemeral insofar as it is destroyed by plowing. The suggested abstraction for Opus is shown in figure 18B. The upper section has been reserved as an upstream contributing area, with ARUP chosen as 0.2 ha. Furrow direction is east-west (across the page). An estimated mean flow length XLP under furrowed flow is 45 m. These numbers specify a mean width of the two surfaces of 121 m. The channel can be longer or shorter than this and should be measured from the map, but preferably on the ground. XLC = 120 m is used here.

Furrows direct the runoff and change the mean flow length, but here the unfurrowed case would have flow lengths similar to those in the furrowed case. This is because the lower right half of the catchment has furrows going nearly straight downslope, and the angle of the furrow with the downslope direction on the left side is not large. Under unfurrowed conditions, especially on the left, downslope flow has a somewhat longer mean length and smaller effective width; 55 m is chosen to represent this on average. The dotted lines in figure 18B show this in simple geometric equivalents, preserving the overall area. The mean channel slope SLA(1,2) or SLA(2,2) can be measured as approximately 0.01. A selected representative slope profile for the surface flow is shown in figure 18C. Slopes at each of the three points shown and their distances from the upper end are entered into the parameter file. A slope profile for the channel can be specified as well, if slopes change significantly along its length.

Line set F01 through F11 is used to describe the hydrologic geometry as described above. The set is read once for the natural topography (KL=1) and again for the furrowed flow geometry (KL=2), unless it is an unmanaged watershed (NTL=0). Data reading includes a check to determine if any tillage operation that creates furrows is included. If not, the program reads only one set of F01-F11 data.

Lines F01 through F06 contain data describing the distributed, shallow-flow area over which runoff flows before entering a concentrated flow path.

F01: IFFIX, ITOCH, MULP(KL), XLP, SLA, PAR, PMN

IFFIX — Flag indicating whether a fixed or unmanaged strip is encountered along the flow path (such as a grass buffer).

- IFFIX=0 — No fixed strip in this element.
- IFFIX=1 — Fixed strip simulated; must be described on line F04.

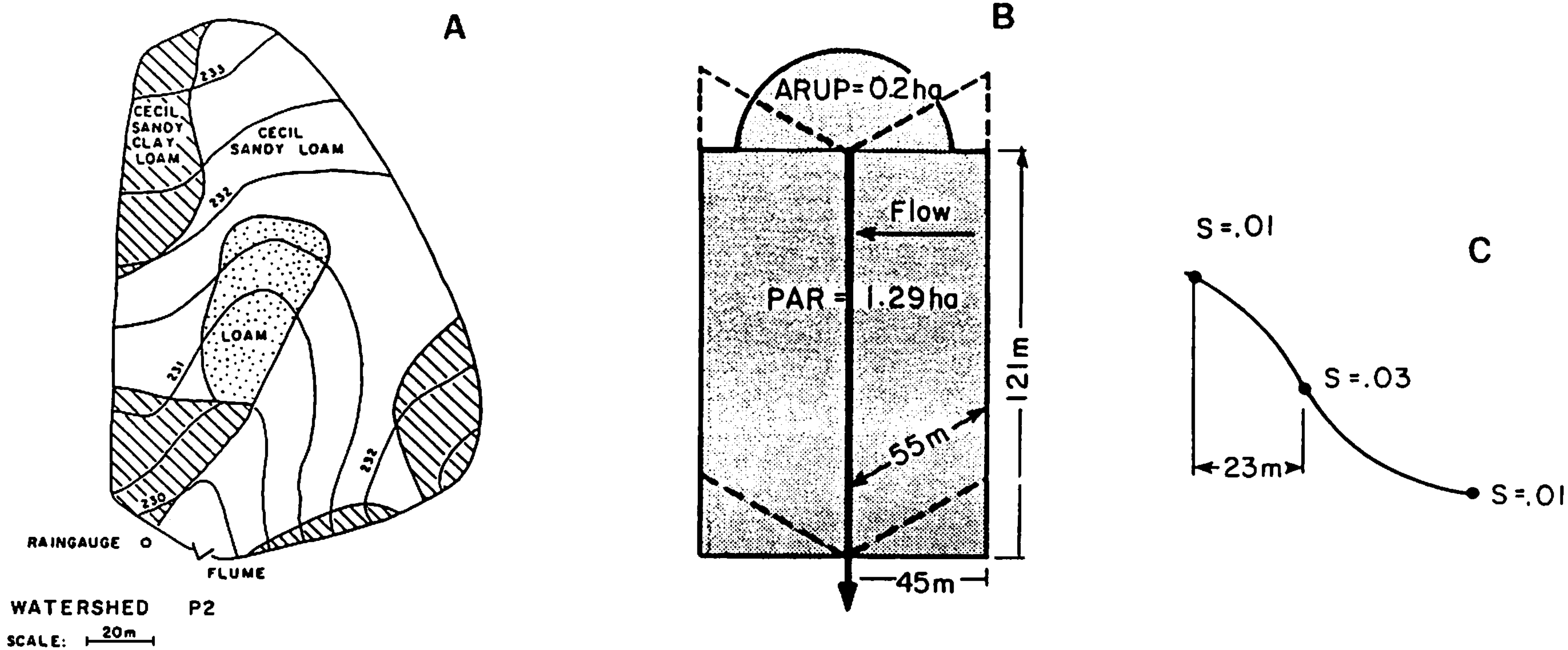

Figure 18. A test field in Watkinsville, GA. A, Topographic map. B, Opus' abstraction of relevant hydrologic geometry. C, Opus' representation of typical profile slopes, using three points along the profile.

ITOCH Indicates presence of a second-order channel.

ITOCH=0 No second-order channel present.
ITOCH=1 Second-order channel to be simulated. Opus will read an additional F07-F10 set describing the second channel for case KL = 2.

MULP(KL) Specifies whether one or two plane units make up the unit catchment that is drained by the first-order channel or concentrated-flow element for flow-path configuration KL. If a single plane with no channel is being simulated, such as a plot experiment, specify MULP(KL)=0. In this case, ITOCH must not be positive (a second channel cannot exist if there is no first channel).

XLP Length of mean flow path before runoff enters the first concentrated flow or channel in this configuration [m or ft].

SLA Mean overall slope of path XLP [m/m or ft/ft].

PAR Total area contributing to the outlet of the first concentrated flow or channel reach [ha or ac]. This area is presumed to be composed of two identical planes if MULP(KL) (above) has been given a value of 2, and will include an upstream direct contributing watershed area (ARUP) specified below. Also, for each value of KL, DA should equal NUN(KL)*PAR [+ ARUP(3), if ITOCH>0].

PMN Manning's n for the first hydrologic element (distributed flow area). This value is used until first tillage operation that changes it. See table 12 for values for many conditions.

Lines F02 and F03 may be used to describe slope complexities.

F02: NPT(KL) Number of points at which the local slope is detailed for path XLP(KL). NPT cannot exceed 10.

F03: XSP(I), SP(I), I=1,5

Line F03 contains pairs of values of XSP(I) and SP(I), with five pairs to a line for as many lines as necessary to read NPT(KL) pairs.

XSP(KL) Distance from the upstream divide to a point at which SP(KL) is specified [m or ft].

SP(KL) Slope at point XSP(KL).

Table 12.
Estimates of Manning's n (PMN and RMNF) for overland flow

Treatment	Condition	Manning's n
Cornstalk residue:		
Applied to fallow interface	1 tn/ac	0.020
	2 tn/ac	0.040
	4 tn/ac	0.070
Disk-harrow incorporated	1 tn/ac	0.012
	2 tn/ac	0.020
	4 tn/ac	0.023
Small grain (20% to maturity):		
Across slope	Poor stand	0.018
	Moderate stand	0.023
	Good stand	0.032
	Dense stand	0.046
Up-and-down slope	Poor stand	0.012
	Moderate stand	0.015
	Good stand	0.023
	Dense stand	0.032
Rough surface depressions:	4 - 5 inches deep	0.046
	2 - 4 inches deep	0.023
	1 - 2 inches deep	0.014
	No surface depressions	0.010
Wheat-straw mulch:	0.25 tn/ac	0.015
	0.5 tn/ac	0.018
	1 tn/ac	0.032
	2 tn/ac	0.070
	4 tn/ac	0.074
Crushed-stone mulch:	15 tn/ac	0.012
	60 tn/ac	0.023
	135 tn/ac	0.046
	240 tn/ac	0.074
	375 tn/ac	0.074
Grass:	Sparse	0.015
	Poor	0.023
	Fair	0.032
	Good	0.046
	Excellent	0.074
	Dense	0.150
	Very dense	0.400

Adapted from USDA (1980), p. 241.

F04: XLFS, XLFE, RMNF, SLRF, PRFF

Line F04 describes an unmanaged (fixed) area that may be included in the field flow path, such as a grassed buffer or waterway, which is not subject to erosive modifications. Line F04 is required, but data are ignored if IFFIX=0 (line F01).

XLFS	Distance to beginning of the fixed or buffer-strip area [m or ft].
XLFE	Distance to end of the fixed or buffer-strip area [m or ft].
RMNF	Manning's roughness coefficient for the fixed area. Table 12 contains RMNF values for various cover conditions.
SLRF	Soil-loss ratio or USLE C factor for erosion potential on the fixed area (should be near 0 for a grass buffer strip).
PRFF	USLE P, cropping practice factor, for the fixed area.

If erosion is simulated (IFSED>0) and if spatially variable soil erodibility is to be used (IVARK>0), lines F05-F06 must describe spatial distribution of the USLE soil erodibility coefficient K. This capability is intended for use only when there is a known and significant change in the erodibility of the soil along the slope. To specify a uniform soil K, set IVARK=0 (line A03), but include these two lines plus templates with dummy or blank data. For variable K, at least two pairs of values should be specified, with one having distance XKS equal to or greater than XLP.

F05: NPK Number of different areas of various soil K's to be specified, up to 10.

F06: XKS(I), USK(I)

There must be NPK F06 templates and lines, listed with five data pairs to a line.

XKS(I)	Mean distance to downstream border of the area I having soil K=USK [m or ft].
USK(I)	USLE soil K [Tn-hr/MJ/mm or t-ac-hr/100 ac-ft/ft-tonf/in] for segment I.

Lines F07 through F10 describe the concentrated flow or channel hydraulic and erosion parameters in much the same manner that lines F01 and F06 do. <u>Lines F07 through F10 are repeated as a set if a second channel is specified (ITOCH>0)</u>.

F07: IFFIX, NUN(KL), NEPH(KL), XLC, SLA(KL,L), ZCA(KL), ARUP(KL,L),WINIT, DINIT, PMN

Line F07 contains the basic data for channel L (L=2 or 3).

IFFIX — Indicates, as for the field surface, if the channel length includes a section not subject to erosion or management changes, such as a grass-lined portion. If greater than zero, this flag causes the program to read data on line F10, which describe the properties of this fixed section.

NUN(KL) — Number of subwatershed units, each with area PAR, making up the area drained by this channel. For a terraced field, when L=2, this represents the total number of terrace units contributing to the outlet channel (L=3).

NEPH(KL) — Flag that indicates channel permanence:

NEPH=0 Channel is permanent.
NEPH=1 Channel is ephemeral and is reset or erosion changes are destroyed by tillage operations.

XLC — Length of channel [m or ft]. For a field that flows without a noticeable channel to an outlet point, XLC may be zero (e.g., see vol. I, fig. 5). A negative value of XLC, equal in absolute value to the input boundary length of the pond, indicates flow of this nature to a pond or impoundment, and other channel data on this line are ignored if not needed. A value for XLC is required so that flow convergence is recognized and computed.

SLA(KL,L) — Mean overall slope of the channel L for hydrology condition KL [m/m or ft/ft].

ZCA(KL) — Mean side slope of the channel section, as a ratio of horizontal to vertical dimensions. ZCA is zero for rectangular channels [m/m or ft/ft].

ARUP(KL,L) Area considered to be contributing directly to the beginning point of the defined channel L [ha or ac]. The remaining area is treated as contributing laterally along the channel length.

WINIT Initial channel bottom width at the channel outlet [m or ft]. Initial bottom width is assumed to decrease as the square root of the relative distance upstream decreases.

DINIT Initial channel depth, assumed uniform along the channel [m or ft].

PMN Manning's n for channel element. Table 13 contains channel n values for many conditions.

Lines F08-F09 describe the channel slope profile and are analogous to lines F02-F03 in the surface flow description.

F08: NPT Number of slope locations specified.

F09: XSP(I), SP(I) (up to five pairs per line)

XSP(I) Distance along path XLC at which slope SP(I) is given [m or ft].

SP(I) Local slope at location XSP(I) [m/m or ft/ft].

F10: XLFS, XLFE, RMNF(KL,L), TAUCF, SLRF, WIDFX(KL,L)

Line F10 data are required if IFFIX>0 (line F07). This line contains data analogous to those in line F04. These data describe the characteristics of the channel section within which are assumed no erosive or management changes with time.

XLFS Distance from the upstream point of the channel to the beginning of the fixed section [m or ft].

XLFE Distance from the upstream point of the channel to the end of the fixed section [m or ft].

RMNF(KL,L) Manning's n for this section. Table 13 contains values for this parameter.

Table 13.
Estimates of Manning's n (RMNF and PMN) for channel flow

Cover	Cover density	Manning's n[1]
Smooth, bare soil; roughness elements	<1 in. deep	0.030
	1-2 in. deep	0.033
	2-4 in. deep	0.038
	4-6 in. deep	0.045
Corn stalks (assumes that residue stays in place and is not washed away)	1 tn/ac	0.050
	2 tn/ac	0.075
	3 tn/ac	0.100
	4 tn/ac	0.130
Wheat straw (assumes that residue stays in place and is not washed away)	1 tn/ac	0.060
	1.5 tn/ac	0.100
	2 tn/ac	0.150
	4 tn/ac	0.250
Grass (assumes that grass is erect and that flow depth does not exceed height of grass)	Sparse	0.040
	Poor	0.050
	Fair	0.060
	Good	0.080
	Excellent	0.130
	Dense	0.200
	Very dense	0.300
Small grain (20% to maturity):		
Rows with flow	Poor, 7-in. rows	0.130
	Poor, 14-in. rows	0.130
	Good, 7-in. rows	0.300
	Good, 14-in. rows	0.200
Rows across flow	Good	0.300
Sorghum and cotton	Poor	0.070
	Good	0.090
Sudangrass	Good	0.200
Lespedeza	Good	0.100
Lovegrass	Good	0.150

[1]Does not include effects of submergence.

From USDA (1980), p. 248.

TAUCF(KL,L) Critical shear for hydraulic erosion in this area [N/m^2 or lbf/ft^2].

WIDFX(KL,L) Width of flow in the fixed-condition reach [m or ft].

The entire group of lines F01-F10 are input for both natural-flow (KL=1) and furrowed-flow (KL=2) geometries. Lines F07-F10 are repeated for ITOCH>0 (F01). The whole data group F01-F10 is not read for the furrowed case (KL=2) only if no management operations have been specified in the data (on line set E) that produce a furrow depth greater than 5 cm (2 in). That logically implies an untilled catchment. The user must be consistent in this regard.

F11: IFOUTL, AV, BV, CV, CQ, EQ, ZQ, RLOSS

Line F11 contains farm pond data used in calculating both the hydrograph and the sediment-concentration distribution in the breakpoint model (IHOP=2) when a farm pond is present (IFPOND>0). For daily simulations (IHOP=1), these values may be blank or zero; lumped pond effects on sediment production must be reflected in parameter PRF on line G04. Line F11 may be blank if a farm pond is not present.

Line F11 contains three parameters that describe the storage shape of the pond according to the following equation:

$$\text{Area} = AV + BV(h)^{CV}$$

where h is pond depth [m or ft], and
AV, BV, CV are shape parameters described below.

Line F11 also contains three parameters that typically describe the outlet-rating relation between depth and discharge:

$$Q = CQ(h - ZQ)^{EQ}$$

where Q is the discharge [m^3/s or ft^3/s], and
CQ, ZQ, EQ are discharge rating parameters (described below).

For IFOUTL = 2, CQ is the orifice diameter, as described below. See volume I for detailed description of the Opus pond component.

IFOUTL Flag indicating whether the pond outlet is given by rating (=1) or by an orifice diameter (=2). This determines the interpretation of parameter CQ.

AV — Conceptual constant base area in the pond area-depth relation [m^2 or ft^2]. (IFPOND=1)

BV — Coefficient in the pond area-depth relation. It represents the surface area of the pond (less the value AV) at water depth of 1 m. (IFPOND=1)

CV — Can assume two alternate definitions, depending on the value of IFPOND:

- IFPOND=1 — CV is the exponent of depth in the pond area-depth relation.
- IFPOND=2 — CV is the slope of the inner face of the impoundment dam (H:V) because this option specifies the use of pond dam, channel, and field slope to geometrically calculate the pond depth-area relation. In this case parameters AV and BV may be used to represent the slopes of the land and channel, respectively, adjacent to the pond. Appropriate default values from the natural hydrologic topography (lines F) are selected if these two parameters are zero.

CQ —
- IFOUTL=1: Outlet discharge rating coefficient for the pond outflow [m^3/min or ft^3/min], or
- IFOUTL=2: Diameter [mm or in] of outlet orifice.

EQ — Outlet discharge rating exponent for pond outflow.

ZQ — Depth in pond below which there is no outflow [m or ft]. This parameter has the same meaning for IFOUTL=1 or 2.

RLOSS — Loss rate from pond bottom; it should be the topsoil saturated conductivity, modified to reflect any pond sealing treatment [mm/hr or in/hr]. For RLOSS=0 or negative, a default of half RC(1) is used.

Group G. Sediment and Erosion Data

The group-G parameters describe attributes of field soil erosion/sedimentation. Data line set G01-G04 must be present in the parameter file, even if erosion is not simulated (IFSED=0 on line A03).

G01: NPS — Number of particle-size classes into which the sediment particle distribution will be divided for simulation. If NPS=0 and IFSED>0, Opus computes five default particle classes based on the PCLAY, PSILT, and PSAND fractions for the uppermost soil layer described on line C02. Maximum value is 5. Fractions (FRASN, etc.) are used to characterize aggregated particles.

G02: DPS(J), RHOP(J), PROSL(J), FRASN(J), FRASL(J), FRACL(J), FRORG(J)

There must be NPS (or 1, if NPS=0) sets of G02 prompts and lines. J is 1 to NPS.

DPS(J)	Mean effective particle diameter for class J [mm or in].
RHOP(J)	Mean effective specific gravity of particle-size class J.
PROSL(J)	Proportion of the total weight of sediment whose particles are within size class J.
FRASN(J)	Fraction of size class J made up of sand-sized particles.
FRASL(J)	Fraction of size class J made up of silt-sized primary particles.
FRACL(J)	Fraction of size class J made up of clay-sized primary particles.
FRORG(J)	Fraction of size class J made up of organic matter.

G03: SSCLY, SSSLT, SSSND, SSORG

Line G03 has basic specific surface area data for the fractions of sand, silt, clay, and organic matter in surface soil, if known. Default values (m^2/m^3) are used if negative numbers are read.

SSCLY	Effective specific surface area of particles in the clay-sized fraction [m^3/m^2 or ft^3/ft^2]. Default = 20.
SSSLT	Effective specific surface area of particles in the silt-sized fraction [m^3/m^2 or ft^3/ft^2]. Default = 4.

SSSND Effective specific surface area of particles in the sand-sized fraction [m^3/m^2 or ft^3/ft^2]. Default = 0.05.

SSORG Effective specific surface area of organic matter in the soil [m^3/m^2 or ft^3/ft^2]. Default = 1000.

G04: ASLK, PRF, EKT(1), EKT(2), EKT(3)

ASLK Mean USLE soil K erodibility factor [t-hr/MJ/mm or tn-ac-hr/100 ac-ft/tonf/in] (see Foster et al. 1981).

PRF USLE cropping practice factor (P). This parameter is used for only IHOP=1, when the MUSLE method is used for estimates of erosion. It must also represent the effect of impoundments, because hydraulic pond routing is not feasible in that option. See volume I for detailed description of the MUSLE option.

EKT(1) A relative erodibility factor in the shear-based calculation for splash erosion (IHOP = 2), for element 1 (distributed flow). [The units are complicated because of empirical exponents, but they are roughly s/m or s/(ft*32)]. The metric EKT value is the English EKT*0.0844. Default value, invoked when a negative number is input, is 0.08679 [metric].

EKT(2) A relative erodibility factor in the shear-based channel or concentrated flow erosion relation (IHOP=2), for element 2. The units are as for EKT(1): metric = English*0.0844. Default value, used when a negative number is input, is 0.246 times the input USLK for the unfurrowed plane [metric].

EKT(3) Analogous to EKT(2), above, for element 3 (the second channel), if any. Setting EKT(3) to zero when ITOCH is positive implies a lined or non-erodible channel. Default value, used when a negative number is input, is 0.246 times the input USLK [metric] for the unfurrowed case.

OPUS METEOROLOGY FILE

The Opus meteorology file always contains weather statistical parameters and may also contain rainfall data or recorded monthly means, from which daily weather data are generated. The climate information is needed to estimate daily potential evapotranspiration and temperature of soil and plant environment and radiation for plant photosynthesis. The method for generating a statistically authentic weather record (daily randomized maximum and minimum temperatures, radiation, and rainfall) is taken from the method of Richardson (1981) as incorporated in the WGEN model (Richardson and Wright 1984). For this model, geographically mean values for each of the necessary parameters have been mapped for the continental United States, and the resulting parameter maps are provided here (app. D, part 2). A more locally accurate option is to read actual monthly mean values for weather data, and to constrain the stochastic sequence to reproduce those means. The optional monthly mean values of local data include daily maximum and minimum temperatures (averaged for each month) and monthly mean incident solar radiation. The user may choose to use monthly mean daily pan evaporation instead of reading radiation and calculating daily potential evapotranspiration by the Penman-Monteith formula (see vol. I).

If available, actual daily radiation and maximum and minimum temperatures may be read in, obviating Opus' predictions of these variables (see "Actual Data File" section).

The program uses the monthly means and amplitude parameters for maximum temperature, minimum temperature, and daily radiation, and from these constructs a smooth Fourier series curve to estimate a mean value for each day of the year for each. If IFRAN (line A03) is 0, these mean daily values are used throughout the simulation. If IFRAN is 1, the other map parameters of standard deviations and cross correlations are used with a random-number generator and probabilistic model to generate a stochastic sequence of daily temperatures and potential evapotranspiration. The stochastic model includes the correlation of these weather values with the rainfall occurrence pattern.

Parameter maps and a table of parameter values for many U.S. cities are given in appendix D. For most purposes, parameter values from the table may be used for nearby locations, or map interpolation may be used when climate and topography are not dissimilar between interpolating locations. For metric input, table 14 contains conversion factors for the English units of the maps. Because of imbedded relationships, <u>English/metric conversions are not a trivial task.</u>

Table 14.
Conversion of weather-generating parameters in appendix D[1] from English to metric units

Parameter	Map/Table units	Conversion[2]
TXMD	°F	$TXMD_c = (TXMC_f-32)*5/9$
TXMW	°F	$TXMW_c = (TXMW_f-32)*5/9$
TN	°F	$TN_c = (TN_f-32)*5/9$
ATX	F°	$ATX_c = ATX_f *5/9$
AMTN	F°	$AMTN_c = AMTN_f *5/9$
CVTX	F°/°F	$CVTX_m = CVTX_e*TXMD_f/(TXMD_f-32)$
ACVTX	F°/°F	$ACVTX_m = ACVTX_e*TXMD_f/(TXMD_f-32)$
CVTN	F°/°F	$CVTN_m = CVTN_e*TXMD_f/(TXMD_f-32)$
ACVTN	F°/°F	$ACVTN_m = ACVTN_e*TXMD_f/(TXMD_f-32)$
BETAG	in	$BETAG_m = BETAG_e*25.4$
RI	in/hr	$RI_m = RI_e*25.4$

[1]This table is provided for users of metric input units who want to utilize the weather data provided in app. D. Note that RMD, AR, RMW, PRW2, PRW1, and ALPHG need no conversion. If monthly temperature values are read, (IFT>0) TAMX and TAMN values must be converted as for TXMD.

[2]Subscripts f and c after each variable name indicate Fahrenheit or Centigrade units. Subscripts m and e represent metric and English units.

The meteorology data consist of two parts: group-H data (statistical information on climate) and group-I/II data (optional rainfall input of either daily (I) or breakpoint (II) form). Group H is the last of the templated input that requires a three-digit line ID at the end of the line. The rainfall data that follow are not in template form and have no such ID's; they are described in detail later. Table 15 describes the formats of the meteorological input lines.

The first line is identifying data. This information is echoed to output files for run-identification purposes. This feature has been added for users making multiple runs and manipulating many input and output data. Experience has demonstrated the ease with which mismatches of watershed and rainfall data may occur. The rainfall-identification line on output files serves the user as either a warning or a positive reinforcement.

Table 15.
Formats for meterologic input lines

Line	Format
H01	(a77,a3)
H02-H13	(12f6.0,t78,a3)
I01	(i5,5x,10f5.2)
II01	(i8)
II02	(3i8)
II03	(10f8.0)

Group H. Climate Statistics

A sample set of climate statistics is illustrated in figure 19. This block of data is the required basis of the meteorology file.

H01: TITLEM Line of title data, echoed to output files for run identification.

H02: TXMD, ATX, CVTX, ACVTX, TXMW

Line H02 contains parameters neccessary to describe the annual trend and variation of daily maximum temperature, using a first-order Fourier series. This line can be blank or zero <u>only</u> if actual daily values are being read in.

- TXMD — Annual mean dry-day maximum temperature [°C or °F].
- ATX — Amplitude of annual variation of TXMD [C° or F°].
- CVTX — Coefficient of variation of daily maximum temperature [C°/°C or F°/°F].
- ACVTX — Amplitude of annual variation of CVTX (assumed to be in phase with daily maximum) [C°/°C or F°/°F].
- TXMW — Mean wet-day maximum temperature [°C or °F].

H03: TN, AMTN, CVTN, ACVTN

Line H03 contains parameters that correspond to the first four parameters of H02 except that they are for daily minimum

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**                                              **

**   M E T E O R O L O G I C A L    D A T A    **

**                                              **

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  TITLE : Enter one line of identifying information
 Bkpt data 73-75, WATKINSVILLE P3                                                        H01
  TXMD   ATX  CVTX ACVTX  TXMW
  73.0  18.0  0.11 -.075  71.5                                                           H02
    TN  AMTN  CVTN ACVTN
  51.5  18.5  0.16  -.13                                                                 H03
   RMD    AR   RMW  SEED
 450.0 175.0 269.0   0.0                                                                 H04
  PRW2  PRW2  PRW2  PRW2  PRW2  PRW2  PRW2  PRW2  PRW2  PRW2  PRW2  PRW2
 0.502 0.490 0.433 0.426 0.462 0.473 0.548 0.437 0.490 0.561 0.385 0.468                 H05
  PRW1  PRW1  PRW1  PRW1  PRW1  PRW1  PRW1  PRW1  PRW1  PRW1  PRW1  PRW1
 0.261 0.291 0.286 0.247 0.188 0.258 0.318 0.208 0.163 0.119 0.207 0.258                 H06
   ------------------------------------------
    The monthly ALFG and BETG values may be
    blank if daily rainfall is not being
    generated (IFGEN on record A04 is not 2)
   ------------------------------------------
  ALFG  ALFG  ALFG  ALFG  ALFG  ALFG  ALFG  ALFG  ALFG  ALFG  ALFG  ALFG
 0.718 0.727 0.689 0.723 0.728 0.765 0.681 0.711 0.661 0.622 0.668 0.743                 H07
  BETG  BETG  BETG  BETG  BETG  BETG  BETG  BETG  BETG  BETG  BETG  BETG
 0.566 0.618 0.734 0.717 0.613 0.453 0.571 0.561 0.671 0.627 0.621 0.589                 H08
    RI    RI    RI    RI    RI    RI    RI    RI    RI    RI    RI    RI
  0.92  0.60  1.03  0.91  1.21  1.17  1.66  1.18  1.46  1.29  1.35  0.83                 H09
   ---------------------------------
    The monthly temp values may be
    blank if IFT on record A04 is 0
   ---------------------------------
  TAMX  TAMX  TAMX  TAMX  TAMX  TAMX  TAMX  TAMX  TAMX  TAMX  TAMX  TAMX
  52.0  53.7  60.3  70.1  79.0  85.7  87.0  86.6  81.8  72.4  61.0  52.4                 H10
  TAMN  TAMN  TAMN  TAMN  TAMN  TAMN  TAMN  TAMN  TAMN  TAMN  TAMN  TAMN
  37.3  38.4  42.5  50.2  60.0  67.5  70.7  69.8  64.3  52.4  41.5  37.1                 H11
   --------------------------------------
    The monthly radiation  values may be
    blank if IFT on record A04 is <2
   --------------------------------------
    RA    RA    RA    RA    RA    RA    RA    RA    RA    RA    RA    RA
 218.0 290.0 380.0 488.0 533.0 562.0 532.0 508.0 416.0 344.0 268.0 211.0                 H12
   ----------------------------------------------------
   Pan coefficient can be blank unless radiation values
   contain evap pan data (IPAN on record A03 is 1)
   ----------------------------------------------------
  TP05   TP6  COEFF
  2.38  4.88    1.2                                                                      H13
[rainfall block (daily or breakpoint) inserted here if IFGEN=0 on A04]
```

Figure 19. Sample meteorology data block (first part of meteorology file).

temperatures. This line may be blank or zero only if actual daily data are being read in.

TN	Annual mean dry-day minimum temperature [°C or °F].
AMTN	Amplitude of annual variation of TN [C° or F°].
CVTN	Coefficient of variation of daily minimum temperature [C°/°C or F°/°F].
ACVTN	Amplitude of annual variation of CVTN [C°/°C or F°/°F].

H04: RMD, AR, RMW, SEED

Line H04 contains daily-radiation statistical parameters, plus a seed for the random-number generator used in the stochastic model computations. This line can be blank or zero only if actual daily radiation data are being read in.

RMD	Annual mean dry-day net solar radiation [ly].
AR	Amplitude of annual variation of daily net solar radiation, R [ly].
PMW	Annual mean wet-day net solar radiation [ly].
SEED	Optional seed value for random number generation. Varying the seed between simulations allows stochastic sequence variation for runs of the same dates. A fixed seed will reproduce the same sequence in each run. SEED can take values between 1 and 999.

H05: PRW(2,M) Probability of a wet day following a wet day for each month [M=1 to 12]

H06: PRW(1,M) Probability of a wet day following a dry day for each month [M=1 to 12]

Lines H07 and H08 are parameters for monthly distribution of rainfall amounts on wet days. A gamma distribution function is assumed. These parameters are used only for IHOP=1 and IFGEN=1 (generating daily rainfall); the lines may otherwise be blank or zeros.

H07: ALFG(M) Gamma-distribution shape parameter for statistical description of daily rainfall amounts on wet days, by month, M=1 to 12.

H08: BETG(M) Gamma-distribution scale parameter for statistical description of daily rainfall amounts on wet days, by month, M=1 to 12.

H09: RI(M)

Line H09 contains rainfall-intensity data, used in daily hydrology (IHOP=1) estimates of runoff peak. This line can be blank or zero only if IHOP=2.

RI(M) Peak 30-min rainfall intensity for months M=1 to 12 [mm/hr or in/hr].

The data on remaining group-H lines are optional; use of these lines depends on the value of IFT (line A04).

H10: TAMX(M) Local mean daily maximum temperatures for each month M=1 to 12 [°C or °F]. These values may be blanks or zeros if IFT=0.

H11: TAMN(M) Local mean daily minimum temperatures for each month M=1 to 12 [°C or °F]. These values may be blanks or zeros if IFT=0.

H12: RA(M) (a) Local mean daily net radiation for each month M=1 to 12 [ly]. (b) Optionally, if IPAN (line A03) is positive, RA represents the monthly mean daily pan evaporation [in or mm], which is multiplied by COEFF to produce RA values. These values may be blanks or zeros for IFT=0 or 1.

H13: TP05, TP6, COEFF

TP05 30-min rainfall depth [mm or in] with a 10-yr return period. Used in estimating runoff peaks if IHOP=1; may be zero or blank for IHOP=2 runs.

TP6 6-hr rainfall depth [mm or in] with 10-yr return period; used like TP05.

COEFF Pan evaporation-to-crop ET coefficient; used when pan data are used instead of solar radiation (IPAN=1 on line A03).

Rainfall Data

If running either the breakpoint option (IHOP=2) or the daily option without rainfall generation (IHOP=1 and IFGEN=0), then rainfall data must be contained here in the meteorology *file*. The template format ceases at this point, because the template is an inconvenience for the amount of input data that may follow. The line-identification system also ceases for the same reason. Lines are described in terms of identifying codes, e.g. I02, but these codes do not appear on the data lines as they must with template data. The format of the rainfall data (table 15) depends on whether it is daily (type I) or breakpoint (type II).

Group I. Daily Rainfall Data

Daily rainfall data are read a year at a time, so they must be in 1-year blocks. If a run is to start or end at midyear (which is often the case), the rest of the year must be filled in with either estimated data or zeros.

Figure 20 illustrates a daily-rainfall block containing 1 year of daily rainfall. The year must be on the first line of each year's rainfall data. Opus does not assume that the first data year is the first year of simulation; instead, Opus reads through the rain data until the specified start year (from line A02) is reached. As with the new title line, this feature was added as a result of experience in making mistakes with a program that does not read the rainfall year. An identifying number (1-37) ends each line in the sample set. This number is not read by Opus, but it is a useful notation for the user in locating data for a particular day and in checking that a full year's data have been entered. Formats are given above in table 15.

I01: IYR, R(I)

IYR — Two-digit year of the first year of rainfall data; need not be present on any other lines, although it is helpful to the user if noted on at least the first data line of each year.

R(I) — Total amount of daily rainfall [mm or in] for day I; listed 10 per line. As discussed above, full 37-line sets must be present for each year in the simulation period.

Group II. Breakpoint Rainfall Data

For the breakpoint hydrology option (IHOP=2), the rain data consist of a variable number of stormwise lines of accumulated depth and time data pairs. A storm is defined as starting after a 180-minute hiatus with no rain accumulation, but the input file may be written with any other storm definition. Opus redefines storms internally if the user's data hiatus criterion is different.

```
*****************************************************
*****************************************************
**                                                 **
**          R A I N F A L L   D A T A              **
**                                                 **
*****************************************************
*****************************************************
```

72	0	0	0	0	0	0	0	0	0	0	1
72	0	0	0	0	0	0	0	0	0	0	2
72	0	0	0	0	0	0	0	0	0	0	3
72	0	0	0	0	0	0	0	0	0	0	4
72	0	0	0	0	0	0	0	0	0	0	5
72	0	0	0	0	0	0	0	0	0	0	6
72	0	0	0	0	0	0	0	0	0	0	7
72	0	0	0	0	0	0	0	0	0	0	8
72	0	0	0	0	0	0	0	0	0	0	9
72	0	0	0	0	0	0	0	0	0	0	10
72	0	0	0	0	0	0	0	0	0	0	11
72	0	0	0	0	0	0	0	0	0	0	12
72	0	0	0	0	0	0	0	0	0	0	13
72	0	0	0	0	0	0	0	0	0	0	14
72	0	0	0	0	0	0	0	0	0	0	15
72	0	0	0	0	0	0	0	0	0	0	16
72	0	0	0	0	0	0	0	0	0	0	17
72	0	0	0	0	0	0	0	0	0	0	18
72	0	0	0	1.20	.30	0	.20	.04	0	0	19
72	0	0	0	0	0	0	0	0	0	0	20
72	0	0	0	0	0	0	0	0	0	.79	21
72	.18	0	.45	0	0	0	0	0	0	0	22
72	0	.32	.43	0	0	0	0	0	0	0	23
72	0	0	0	0	0	.68	0	0	0	0	24
72	0	0	0	0	0	0	0	1.94	0	0	25
72	0	0	0	0	0	0	0	0	0	0	26
72	.05	.23	0	0	0	0	0	0	0	0	27
72	0	0	0	.50	0	0	0	0	.25	0	28
72	0	0	0	0	0	0	.07	0	0	0	29
72	0	0	0	0	0	0	.29	0	0	0	30
72	1.27	0	.09	0	0	0	0	.10	0	0	31
72	0	.97	0	0	0	0	0	.45	0	0	32
72	0	0	0	1.02	0	0	0	0	0	0	33
72	.85	0	0	0	.18	0	0	0	0	0	34
72	.61	.24	0	0	0	0	0	0	2.99	1.60	35
72	0	0	0	0	.21	1.80	.92	0	0	0	36
72	0	0	0	0	0	.80	0	0	0	0	37

Figure 20. Sample of data block for daily rainfall (option IHOP=1, second part of meteorology file).

Figure 21 exemplifies the breakpoint rainfall data that must be appended to the meteorology template when IHOP=2.

II01: IFJULB Flag indicating that the dates following have Julian-date format. Format I8.

IFJULB=0	Not Julian; dates are of the form mmdd (e.g., 0228 for February 28).
IFJULB=1	Julian dates, of the form jjj (e.g., 059 for February 28).

```
****************************************************
****************************************************
**                                                **
**              R A I N F A L L   D A T A         **
**                                                **
****************************************************
****************************************************
       0
      72       7 2         5         0       0.45
    0.00    957.00      0.15    960.00       0.40    964.00     0.44   970.00     0.45   992.00
      72       7 2         5         0       0.75
    0.00   1140.00      0.45   1196.00       0.60   1200.00     0.72  1208.00     0.75  1227.00
      72       7 3         5         0       0.30
    0.00   1231.00      0.10   1233.00       0.25   1235.00     0.29  1238.00     0.30  1240.00
      72       7 5         4         0       0.20
    0.00     13.00      0.05     15.00       0.15     35.00     0.20  1440.00
      72       7 6         2         0       0.04
    0.00     65.00      0.04     97.00
      72       728         8         0       0.79
    0.00   1198.00      0.15   1200.00       0.25   1203.00     0.27  1206.00     0.45  1210.00
    0.73   1215.00      0.75   1230.00       0.79   1250.00
```

Figure 21. Sample of data block for breakpoint rainfall (option IHOP=2, second part of meteorology file).

Lines II02-II03 make up a storm rainfall set and are repeated for all storms in the simulation period. Stormwise information consists of two or more data lines. Each storm has an II02 line and then as many II03 lines as necessary to describe all the breakpoints in the storm. The II02 line contains only storm-summary data. Formats are given in table 15.

II02: JYR, NDAY, NP. Format 3I8 (right justified)

JYR	Two-digit year.
NDAY	Day of year, either mmdd or jjj, depending on IFJULB above.
NP	Number of breakpoints (time-depth pairs) in storm (maximum allowed is 200).

II03: BP(I), T(I)

There must be NP pairs of BP and T data pairs, and no more than five pairs per line. Format is 10f8.0.

BP (I)	Depth of cumulative storm rainfall. If the first point is 0.0, the last is total storm depth.
T(I)	Time of breakpoint reading [min since midnight of storm-start day]; if greater than 1440, storm has crossed midnight.

ACTUAL DATA FILE

Opus includes an option for the input of several daily variables that may be used in lieu of simulated values. The data that may be included on this file are "actual" (measured) daily runoff, peak runoff rate, erosivity index, sediment outflow, maximum and minimum temperatures, and measured incident solar radiation. Many combinations of these data may be present and/or used from this file. This actual hydrology data is usable only by the daily hydrology option, except temperature and radiation data, which can be used by either hydrology option. The reading of measured data on this file obviates Opus simulation of any of these variables.

Figure 22 shows a portion of a sample actual data file.

Group J. Actual Data

J01: TITLEA Line of identifying data, as with all input files, to be written on all output files.

J02: IFJUL, IRLRO, IRLQP, IRLEI, IRLSD, IRLTM, IRLRD

Line J02 contains a set of flags, each located above its respective column of measured data, indicating whether or not the appropriate data are to be read from that file in the simulation. Thus the user does not need to remove a column of data to activate Opus simulation of a process; the flag need only be changed to zero. The input format is (7i8). The flags and their meanings are summarized as follows:

IFJUL Flag indicating use of Julian dates.

IFJUL=0 Date is given in the form of mmddyy.
IFJUL=1 Date is given in the form of yyjjj, in which jjj is the Julian day.
Example:

Date	IFJUL=0	IFJUL=1
Jan. 3, 1988	010388	88003

IRLRO Flag indicating if daily runoff is to be read from the following data lines: 0=no, 1=yes

IRLQP Flag indicating if peak discharge data are to be read from the following data line: 0=no, 1=yes.

****RAINFALL SIMULATOR - ACTUAL WEATHER DATA****

0	1	1	1	0	1	1	
061888	0.0	0.00	0.00		33.0	18.0	550.0
061988	0.0	0.00	0.00		33.0	18.0	550.0
062088	3.8	0.02	0.11		34.0	17.3	568.8
062188	0.3	0.00	0.00		33.8	18.1	375.2
062288	0.6	0.00	0.00		33.6	18.9	442.2
062388	8.1	0.04	0.31		32.6	15.2	521.0
062488	0.0	0.00	0.00		37.8	15.9	657.3
062588	7.1	0.00	0.00		33.2	19.2	289.2
062688	0.0	0.00	0.00		30.7	18.5	650.1
062788	1.0	0.00	0.00		30.0	17.3	671.6
062888	4.8	0.00	0.00		31.2	15.8	657.3
062988	9.7	0.00	0.00		28.7	18.2	411.1
063088	0.0	0.00	0.00		26.6	17.9	690.7
070188	3.2	0.04	0.06		29.6	16.7	721.8
070288	0.0	0.00	0.00		32.2	13.9	475.6
070388	0.0	0.00	0.00		34.5	13.7	592.7
070488	0.0	0.00	0.00		33.2	16.2	523.4
070588	3.5	0.05	0.04		33.1	15.4	588.0
070688	0.0	0.00	0.00		33.1	18.8	530.6
070788	14.8	0.85	4.98		28.4	18.6	487.6
070888	3.3	0.00	0.00		29.1	16.8	401.5
070988	0.3	0.00	0.00		28.1	15.1	640.5
071088	9.7	0.01	0.19		28.9	14.2	561.7
071188	0.0	0.00	0.00		29.7	13.1	501.9
071288	4.8	0.00	0.00		33.9	13.9	518.6
071388	0.0	0.00	0.00		33.6	18.3	676.4
071488	0.3	0.00	0.00		32.6	19.8	425.4
071588	7.3	0.03	0.25		29.7	16.9	420.7
071688	0.0	0.00	0.00		31.3	15.5	537.8
071788	0.0	0.00	0.00		28.9	16.7	544.9
071888	1.3	0.00	0.00		28.7	14.8	585.6
071988	4.3	0.00	0.00		21.9	12.6	382.4
072088	10.0	0.03	0.14		25.1	9.6	676.4
072188	0.0	0.00	0.00		33.6	10.3	671.6
072288	16.8	0.09	0.10		32.2	13.5	611.9
072388	0.0	0.00	0.00		24.6	13.4	449.3
072488	0.0	0.00	0.00		31.9	13.7	657.3
072588	11.9	0.03	0.05		32.6	13.6	396.7
072688	0.0	0.00	0.00		31.5	14.5	559.3
072788	8.1	0.03	0.79		32.1	14.9	533.0
072888	0.0	0.00	0.00		29.4	16.9	286.8
072988	1.3	0.76	6.00		31.8	18.1	511.5
073088	0.0	0.00	0.00		31.4	16.5	621.4
073188	0.0	0.00	0.00		31.5	17.2	403.9
080188	0.0	0.00	0.00		34.0	14.8	468.5
080288	3.3	0.00	0.00		34.2	15.2	535.4
080388	12.7	0.30	0.34		28.2	17.3	427.8

Figure 22 (Corrected). Sample actual data file

IRLEI — Flag indicating if storm erosivity index (EI) data are to be read from the following data lines: 0=no, 1=yes.

IRLSD — Flag indicating if measured sediment-outflow total is to be read from the following data lines: 0=no, 1=yes.

IRLTM — Flag indicating if daily values of both maximum and minimum temperatures are to be read from the following data lines: 0=no, 1=yes. Note that both must be present. Note also that for this and for measured radiation, data must be given for every day of the simulation period. For data on runoff and sediment (covered by the first five flag parameters), the data need be given only on days with rainfall or runoff events.

IRLRAD — Flag indicating if values of daily incident radiation are to be read from the following measured data file: 0=no, 1=yes.

J03: IRLDA, ACTRO, ACTQP, ACTEI, ACTSD, TCMX, TCMN, RD

The format of line J03 is (i8, 7f8.0).

IRLDA — Date, either as a year and Julian day [yyjjj] or as a calendar date [mmddyy], depending on the value of IFJUL, discussed above. The dates must be in chronological order.

ACTRO — Measured runoff on day IRLDA [mm or in].

ACTQP — Measured value of peak runoff rate [mm/hr or in/hr].

ACTEI — Measured value of rainfall EI (erosivity index) for day IRLDA [units of MJ-mm/ha/hr or 100ft-tn-in/ac/hr] (see Foster et al. 1981). This data item is unlikely to be available unless breakpoint rainfall data are available to make possible such computations to supplement daily data.

ACTSD — Measured sediment in runoff for day IRLDA [kg/ha or lb/ac].

TCMX — Measured value of daily maximum temperature [°C or °F].

TCMN — Measured value of daily minimum temperature [°C or °F].

RAD Measured value of daily incident solar radiation [ly/day].

Any data ACTRO through ACTSD can be read occasionally (when storms occur); i.e., a line of data is necessary on only the days when an event occurs. If actual values of temperature and/or radiation are used, a data line is required for every day within the simulation.

OPUS OUTPUT OPTIONS

Opus offers several options for output data, ranging from a simple result summary to massive, detailed information. The extent and frequency of output are specified by the user through interactive file selection at the start of a run, and through the input parameters IFWRDA, INTSP, THRESH, and IFOUT. The user should check all these values before beginning a run, and the information from the user at the run start should be consistent with these parameter values.

The four output files are a main (standard) file, an optional surface file, a subsurface file, and a plant file. An optional screen output tracks the simulation progress.

Screen Output

Parameter IFWRDA (line A03) governs writing to the screen (or log file, if a batch run) during the simulation. All that is printed is the Julian date of the day being simulated (yyjjj), so the user can see how the run is progressing.

File Output

Standard Output. This output includes summary information based on the input data, including a summary of field topography, description of crops, and information on soil hydrologic parameters and particle size distribution. Any detected errors in parameter input are flagged here. Errors include warnings (the simulation proceeds, but the user is notified that a parameter value is questioned), changes (an unreasonable input value has been changed to something reasonable), and stops (the error causes an abrupt program stop). A common error is miscounting by the user when adding or deleting data lines; the program writes the numbered line expected and the contents of columns 78-80 of the line encountered.

The output soil-layer parameters include both read-in and synthesized (default) information, and should be checked for reasonableness of default values. Compare these values to those in table 6; if the defaults are outside the recommended ranges for the type of soil being described, a value can be input to override the default. Figure 23 is a sample of the first part of the standard output file, in which the input data are described.

The simulation-results section of the standard output is controlled by parameter IFOUT (line A03). If IFOUT=0, only an annual monthly result summary is produced, an example of which is

O p u s simulation run

(BREAKPOINT PRECIPITATION VALUES)

PARAMETER TITLE:
WATKINSVILLE, GA., Catchment P-3 EPA management data

73-75(length of precip record Breakpoint run
PRECIP TITLE:
Bkpt data 73-75, WATKINSVILLE P3

CROP	MAX. LAI	MATURITY DEG.C-DAYS	POTENT. DRY MATTER, KG/HA: TOTAL	YIELD	MAX. ROOT DP. MM	MAX. SOIL COVER	POTENT HEIGHT M	MIN. GROWTH DAYS	SPECIF. TOPS WT. G/CM2
win.rye	3.00	1388.9	4483.	54.	609.6	0.80	0.61	29.	0.147
soybean	4.00	2000.0	10087.	2578.	609.6	0.60	1.22	61.	0.229
Barley	3.00	1944.4	6725.	538.	609.6	0.80	0.91	43.	0.202

NATURAL FIELD COMPOSED OF 6 UNITS, EACH WITH CHANNEL OF 79.9
M. FED BY 1 PLANE(S) 26.2 M. LONG
OF 2096.35SQ.M. EACH. TOTAL AREA= 12586.2 SQ.M. 5 9
FURROWED FIELD COMPOSED OF 1 UNITS, EACH WITH CHANNEL OF 78.6
M. FED BY 2 PLANE(S) 79.9 M. LONG
OF 6293.09SQ.M. EACH. TOTAL AREA= 12586.2 SQ.M. 9 9
0METRIC POND PARAMETERS 1.393 2000. 2.000 46.772 2.050 0.000 0.042
/ EROSION COEFFICIENTS USED ARE:
EKT(PLANE)= 0.01008 EKT(CHAN1) = 0.01134 EKT(CH2) = 0.01134

4 SOIL HORIZONS DIVIDED INTO 17 COMPUTATIONAL LAYERS
11 LAYERS USED FOR SOLUTE TRANSPORT CALCULATIONS (IPRK).
10 IS LAYER BELOW MAX ROOTING DEPTH (ILBR)

SOIL LAYERS SET AS FOLLOWS:

HOR	COM LAY	NUT LAY	DEPTH (MM)	SAT CON (MM/M)	PBUB (MM)	ALAM	THR	THS	INIT POT (MM)	THETA	N03 (KG/HA)
1	1	2	10.	0.2328	-124.5	0.3448D	0.1112	0.3300	-1668.	0.2000	11.726
1	2	2	40.	0.2328	-124.5	0.3448D	0.1112	0.3300	-1668.	0.2000	35.179
1	3	2	96.	0.2328	-124.5	0.3448D	0.1112	0.3300	-1668.	0.2000	65.902
1	4	2	152.	0.2328	-124.5	0.3448D	0.1112	0.3300	-1668.	0.2000	65.902
2	5L	2	229.	0.1270	-127.0	0.1976D	0.2041	0.3500	-1668.	0.2915	66.637
2	6	3	305.	0.1270	-127.0	0.1976D	0.2041	0.3500	-1668.	0.2915	66.637
3	7	3	406.	0.1317D	-165.6D	0.2102D	0.2425	0.4000	-1668.	0.3389	20.597
3	8	3	508.	0.1317D	-165.6D	0.2102D	0.2425	0.4000	-1668.	0.3389	20.597
3	9	3	610.	0.1317D	-165.6D	0.2102D	0.2425	0.4000	-1668.	0.3389	20.597
4	10	3	762.	0.4123D	-127.6D	0.3057D	0.2580	0.4500	-1668.	0.3450	12.358
4	11	3	953.	0.4123D	-127.6D	0.3057D	0.2580	0.4500	-1668.	0.3450	15.448

NOTE: D BESIDE VALUE INDICATES CALCULATED DEFAULT
L Beside layer number indicates flow limiting layer

PARTICLE SIZE DISTRIBUTION DATA, IN ORDER OF TRANSPORTABILITY

CLASS	EQUIV DIAM	SIZE (MM)	SPEC. GRAV.	PROPN. IN SOIL	FRACTION COMPOSITION SAND	SILT	CLAY	VSETL (MM/SEC)
1	0.0020	0.0020	2.60	0.044	0.000	0.000	1.000	0.509E-04
2	0.0100	0.0100	2.65	0.020	0.000	1.000	0.000	0.131E-02
3	0.0300	0.0209	1.80	0.170	0.000	0.528	0.472	0.572E-02
4	0.2000	0.2000	2.65	0.252	1.000	0.000	0.000	0.522
5	0.3400	0.2049	1.60	0.514	0.755	0.157	0.088	0.548

Figure 23. Sample of standard output initial summary.

shown in figure 24. If the nutrient simulation option is not selected, the annual summary is similar to that shown in figure 24 except that the last two columns (on nitrogen leached and in runoff) are omitted. The second set of monthly columns report the history of crop stress due to N and water deficits. The data on stress are given in terms of stress-days, with a day during which the respective relative stress is 0.8 counting as 0.8.

IFOUT=1 produces a more detailed standard output file, a sample of which is shown in figure 25. The simulation start and end dates are noted. A line of output is generated for each rain event, summarizing hydrologic results. All management actions are indicated. This output option is recommended for most applications, but it may be omitted for very long runs.

Optional Detailed Surface-Hydrology Results. Optional surface-hydrology output is governed by parameter THRESH (A02). This file contains detailed storm information, including rainfall, infiltration, and runoff hydrographs. It may also contain information about runoff of nutrients and pesticides if those options are being simulated. Figure 26 is a sample of hydrology file output for one event.

Optional Detailed Subsurface-Hydrology Results. Optional subsurface output is governed by parameter INTSP (line A02). Like the detailed surface file, this subsurface file always contains information about soil hydrology and may contain information about nutrients and pesticides, depending on options being simulated. Figure 27 is a sample subsurface output, representing the report for one day, when both IFNUT and IFPEST are positive. At the beginning of this output file (not shown in this figure) is a table for each soil horizon, showing the soil hydraulic relations $\theta(h)$ and $k_r(h)$.

Optional Crop Status File Output. From the interactive run start, this option can be selected. The data produced (as shown in fig. 28) include date, root depth and ALAI data for up to four crops, total leaf area index, total relative soil cover, and standing dry matter. The three columns allowed for concurrent crop information are reset and the respective crop numbers are noted at the end of each year.

Optional Residue Status File Output. This optional output is also selected from the interactive startup. Information on the nutrient cycling and residue decay model is produced, at monthly intervals. The output data correspond to the conceptual pools of matter in the soil plus the mobile mineral material, and the column titles in figure 29 show the data that are included.

ANNUAL SUMMARY FOR CROP YEAR 1973

	Precip	Runoff	E.T.	Seepage	Profile Water	Sediment	Nitrate	
							Leach	Runoff
	MM	MM	MM	MM	MM	T/HA	KG/HA	
					230.77			
APR	100.84	.00	71.36	36.42	223.83	.000	36.95	.00
MAY	166.12	23.95	76.79	55.14	234.06	.278	79.44	.82
JUN	121.16	16.35	70.40	44.67	223.80	1.641	66.01	.49
JUL	123.19	39.56	78.68	9.28	219.47	3.081	12.40	.70
AUG	22.86	.00	58.33	-10.37	194.37	.000	-13.43	.00
SEP	135.13	22.20	82.21	-.16	225.25	1.325	-.32	1.12
OCT	5.08	.00	42.70	-8.94	196.57	.000	-11.24	.00
NOV	43.18	.09	23.83	-7.60	223.42	.038	-9.37	.01
DEC	182.63	15.46	40.77	63.30	286.52	1.911	72.35	.15
TOT	900.18	117.62	545.07	181.74		8.274	232.78	3.29

	NSTRESS	DAYS	WSTRESS	DAY
APR	1.0000	1.0	.0765	1.0
MAY	.0000	.0	.0000	.0
JUN	.0000	.0	.0000	.0
JUL	.0000	.0	.0000	.0
AUG	.0000	.0	14.0895	17.2
SEP	.0000	.0	6.6205	8.1
OCT	22.9854	23.0	.0000	.0
NOV	.0000	.0	14.2258	14.6
DEC	.0000	.0	.0000	.0

Figure 24. Sample of standard output, annual summary of hydrologic balance.

DATE MMDDYY	PRECIP MM	RUNFF MM	Q PEAK MM/HR	PERC MM	AVG TEMP C	SOIL MOIS MM/MM	TRANS MM	EVAP MM	SED YIELD T/HA	ENR RAT	MANAGEMENT OPERATIONS
043073											SIMULAT. START
050273	10.16			0.52	18	.3107	0.00	3.58			
050873	16.00			1.88	18	.3155	0.00	10.46			
052273											FERTILIZED
052273											DISK hr
052373	22.10			3.60	19	.3289	0.00	12.40			
052873	48.26	15.28	4.72	7.47	20	.3449	0.00	13.29	0.14	1.58	
060573	6.86			1.99	27	.3090	0.00	9.27			
060673	39.37	15.06	28.46	0.19	26	.3389	0.00	1.79	1.83	1.56	
060773	20.07	0.53	1.68	10.32	27	.3474	0.00	2.74	0.10	1.75	
061373	8.89	0.22	0.67	2.25	29	.3130	0.00	7.04	0.06	1.95	
061473											APPLIED PARAQ
061573											plntsoy
070473	1.27			0.01	26	.2915	2.40	6.23			
070873	64.26	32.65	22.54	-0.21	25	.3278	2.35	1.77	1.87	1.58	
071473	19.05	5.77	16.97	5.80	27	.3079	9.53	13.05	0.42	1.61	
092773	5.08			-0.77	21	.2721	29.93	7.09			
092873	6.35			-0.45	22	.2730	4.16	2.00			
093073	13.72			-0.57	17	.2816	5.40	2.34			
100573											plntrye
103173	5.08			-5.97	14	.2567	25.69	4.39			
110773											hvst sy
						1408.6 KG/HA soybean YIELD					
112173	20.83	0.03	0.06	-2.95	10	.2759	7.25	1.91	0.00	2.37	
120473	1.27			0.05	10	.2930	0.59	4.83			
120573	38.61	0.02	0.03	0.25	10	.3422	0.01	0.81	0.00	2.72	
121573	18.29			22.87	13	.3245	0.36	8.56			

------------ NOTE: S = SNOWFALL, I = IRRIGATION, M = SNOWMELT ------------

Figure 25. Sample of optional stormwise hydrologic output for standard output file.

EVENT RUNOFF OUPUT FILE FOR RAINS OVER 33.782 MM
PARAMETER INPUT TITLE:
WATKINSVILLE, GA., Catchment P-3 EPA management data

73-75(length of precip record Breakpoint run
RAINFALL TITLE:
Bkpt data 73-75, WATKINSVILL P3

HYDROGRAPH FOR RAINFALL OF 48.26 MM ON MAY 28 73:

UNFURROWED SURFACE FLOW CONFIGURATION

TIME MIN	RAIN RATE MM/HR	INFIL RATE MM/HR	PLANE DISCHRG MM/HR	OUTLET DISCHRG MM/HR	ACCUM RUNOFF MM	SEDIMENT DISCHRG KG/MIN
231.000						
258.083	26.469	26.360	0.000	0.000	0.000	0.00
264.000	26.469	23.253	0.192	0.000	0.000	0.00
266.500	55.033	18.119	7.129	0.000	0.000	0.00
268.500	55.033	17.815	17.543	0.006	0.000	0.00
269.500	55.033	17.672	22.873	0.029	0.001	0.01
273.385	55.033	17.352	35.091	0.514	0.034	0.22
275.709	55.033	16.975	37.215	1.036	0.074	0.62
282.000	55.033	16.243	38.423	3.492	0.330	3.63
287.773	18.288	12.372	12.213	4.688	0.745	5.95
289.593	18.288	12.341	9.806	4.721	0.888	6.20
302.500	40.640	12.155	9.516	2.187	1.623	2.83
303.500	40.640	12.146	12.302	2.097	1.658	2.61
304.500	40.640	12.134	15.134	1.986	1.691	2.39
308.000	40.640	12.100	23.423	1.822	1.800	1.92
308.500	1.249	12.091	21.990	1.821	1.815	1.88
312.918	1.249	12.023	4.963	1.995	1.958	1.82
338.355	1.249	1.249	0.000	0.321	2.437	0.49
342.685	1.249	1.249	0.000	0.207	2.452	0.31
352.685	1.249	1.249	0.000	0.086	2.470	0.11

SUMMARY OF SURFACE RUNOFF FOR MAY 28 73:
RUNOFF OF 15.278 MM, SEDIMENT YIELD 0.1405 T/HA
NUTRIENTS IN RUNOFF: NO3= .0000E+00, NH4= .0000E+00, PO4= .0000E+00 G/HA
PESTICIDES AND RESPECTIVE RUNOFF AMOUNTS IN G/HA:

TRIFLUR,	0.000220 WITH SEDIMENT,	0.031704 DISSOLVED
PARAQ,	1.764867 WITH SEDIMENT,	0.009522 DISSOLVED
DIPHENA,	0.000015 WITH SEDIMENT,	0.003168 DISSOLVED

Figure 26. Sample of optional detailed surface hydrology output file.

****

SUBSOIL STATUS AS OF DEC 31 73 :

LAYER NO.	DEPTH (MM) FROM:	TO:	TEMP. DEGC	WATER CONTENT	CAPILLARY HEAD, MM
1	.00	10.00	2.5	.3300	-1.0
2	10.00	40.00	3.5	.3298	-21.5
	***				
10	609.60	762.00	11.9	.4006	-303.1
11	762.00	952.50	12.6	.4006	-303.1

MOBILE NUTRIENTS IN ROOTZONE LAYERS:

LAYER NO.	DEPTH (MM) FROM:	TO:	NITRATE [KG/HA]	AMMONIA [KG/HA]	PHOSPHATE [KG/HA]
1	.00	10.00	.030	.029	12.730
2	10.00	40.00	.091	.699	18.118
	***				
10	609.60	762.00	64.420	2.442	10.572
11	762.00	952.50	97.370	2.678	1.566
	At Depth	952.50	99.5 ppm	Below Roots During Interval	

PESTICIDE TOTALS IN ROOT ZONE LAYERS:

LAYER NO.	DEPTH (MM) FROM:	TO:	TRIFLUR GM/HA	PARAQ GM/HA	DIPHENA GM/HA
1	.00	10.00	.4277E-01	1057.	.3026E-04
2	10.00	40.00	.5228	2191.	.5029E-03
	***				
10	609.60	762.00	.1355	.2222E-01	.1027E-01
11	762.00	952.50	.9416E-01	.1139E-01	.4315E-02

Accounting of Applied Chemicals for Year 1973

Month	Chemical Name	Total Input	Lost in Air/Hvst	Decayed	Resident	Runoff Out	Seep Out
			--- gm./ha.---				
	TRIFLUR	38.8248					
	PARAQ	8423.736					
	DIPHENA	11.595					
APR	TRIFLUR	38.8248	.0000	22.2403	16.5809	.0000	.0035
	PARAQ	8423.736	.000	295.063	8128.675	.000	.000
	DIPHENA	11.595	.000	10.475	1.121	.000	.000
MAY	TRIFLUR	38.8248	.0000	31.2185	7.5395	.0210	.0457
	PARAQ	8423.736	.000	595.989	7825.024	2.724	.000
	DIPHENA	11.595	.000	11.436	.158	.000	.001
JUN	TRIFLUR	599.2398	.0000	245.3262	353.7544	.0379	.1203
	PARAQ	9959.274	.000	922.886	9019.452	16.934	.000
	DIPHENA	3374.085	.000	2339.075	1034.961	.044	.003

[***] indicates where lines have been omitted for illustrative clarity.

Figure 27. Sample of optional detailed subsurface hydrology output file. [***] indicates where lines were deleted so that all sections can be shown.

WATKINSVILLE, GA., Catchment P-3 EPA management data

73-75 length of precip record Breakpoint run
Crop 1 is win.rye

JDAY	1: Root	DM.	2: Root	DM.	3: Root	DM.	TLAI	PFCOV	StDry
4 173	598.9	2190.3	.0	.0	.0	.0	1.86	.572	44.9
4 273	599.2	2261.3	.0	.0	.0	.0	1.92	.586	44.5
4 373	600.6	2356.1	.0	.0	.0	.0	2.00	.604	44.0
4 473	602.2	2418.7	.0	.0	.0	.0	2.05	.615	43.6
4 573	603.1	2459.1	.0	.0	.0	.0	2.08	.622	43.1
4 673	603.6	2481.4	.0	.0	.0	.0	2.09	.625	42.7
4 773	603.6	2486.5	.0	.0	.0	.0	2.10	.626	42.3
4 873	603.6	2514.8	.0	.0	.0	.0	2.12	.631	41.9
4 973	603.6	2560.7	.0	.0	.0	.0	2.15	.638	41.4
41073	603.6	2623.0	.0	.0	.0	.0	2.20	.647	41.0
41173	603.6	2684.6	.0	.0	.0	.0	2.25	.655	40.6
41273	603.6	945.6	.0	.0	.0	.0	.26	.082	40.2
41373	603.6	981.5	.0	.0	.0	.0	.30	.097	39.8
-----(skipped)---------------									
52073	603.6	981.5	.0	.0	.0	.0	.20	.062	26.6
52173	603.6	981.5	.0	.0	.0	.0	.19	.062	26.4
52273	.0	.0	.0	.0	.0	.0	.00	.000	13.1
-----(skipped)---------------									

Crop 2 is soybean

JDAY	1: Root	DM.	2: Root	DM.	3: Root	DM.	TLAI	PFCOV	StDry
61573	.0	.0	10.0	.0	.0	.0	.00	.000	9.8
61673	.0	.0	10.0	.0	.0	.0	.00	.000	9.7
61773	.0	.0	10.0	.0	.0	.0	.00	.000	9.6
61873	.0	.0	10.0	.0	.0	.0	.00	.000	9.5
61973	.0	.0	10.0	8.9	.0	.0	.00	.001	9.4
62073	.0	.0	13.2	13.6	.0	.0	.01	.002	9.3
62173	.0	.0	14.8	17.8	.0	.0	.01	.003	9.2
62273	.0	.0	16.3	29.8	.0	.0	.02	.005	9.1
62373	.0	.0	20.6	40.6	.0	.0	.03	.007	9.0
62473	.0	.0	24.4	52.8	.0	.0	.04	.009	8.9
62573	.0	.0	28.6	66.5	.0	.0	.04	.011	8.8
62673	.0	.0	33.4	85.3	.0	.0	.06	.014	8.7

Figure 28. Sample of optional crop data output file. Lines have been deleted in two places for clarity. DM and StDry are in kg/ha, and root depths are in mm.

WATKINSVILLE, GA., Catchment P-3   EPA management data

73-75 length of precip record   Breakpoint run

Modified Century Soil Organic Matter Model Carbon Variables

day	strucc(1)	metabc(1)	strucc(2)	metabc(2)	som1c	som2c	som3c
1/ 4/73	3.755	3.3896	37.478	86.7571	119.69	1195.10	1673.23
1/ 5/73	3.672	2.5604	35.478	50.0903	126.70	1191.84	1673.24
1/ 6/73	2.698	2.3003	38.022	30.0055	125.59	1185.89	1673.22
1/ 7/73	.236	.1241	36.050	8.5278	113.38	1177.31	1673.21
1/ 8/73	.323	.3027	32.021	2.1984	97.35	1166.48	1673.18
1/ 9/73	1.429	2.6803	29.980	1.0415	89.53	1159.60	1673.15
1/10/73	2.213	2.6680	27.680	.4203	81.78	1150.66	1673.10
1/11/73	2.194	1.8779	26.510	.2580	77.94	1145.57	1673.08
1/12/73	2.188	1.6331	26.037	.2107	76.41	1143.39	1673.05

day	strucc(1)	metabc(1)	strucc(2)	metabc(2)	som1c	som2c	som3c
1/ 1/74	2.382	2.0457	32.615	22.7369	77.45	1139.83	1673.00
1/ 2/74	7.988	20.9372	32.516	18.6017	78.69	1137.28	1672.98
1/ 3/74	11.720	30.6934	32.020	15.0401	80.27	1135.18	1672.96
1/ 4/74	14.681	32.8907	31.189	10.4434	82.80	1131.70	1672.94
1/ 5/74	16.428	27.2740	31.769	10.2536	84.92	1126.45	1672.90
1/ 6/74	.972	1.2451	48.430	24.5467	86.84	1118.10	1672.83
1/ 7/74	.838	1.1819	45.120	7.2829	82.67	1106.87	1672.73
1/ 8/74	1.158	1.9201	42.530	2.9170	76.25	1097.05	1672.65
1/ 9/74	3.708	5.7072	39.573	1.0431	70.51	1086.89	1672.55
1/10/74	3.967	3.9259	37.573	.4991	66.98	1079.34	1672.47
1/11/74	18.351	40.9873	54.238	51.5325	69.26	1075.65	1672.44
1/12/74	18.367	30.2667	52.880	34.1382	78.57	1072.10	1672.40

Figure 29. Sample of optional output of monthly summary of major pools in the Opus modified Century residue and nutrient model. Dates are in dd/mm/yy format, and other units are in g/m^2.

Two options are available: a short 80-column version (shown), and a long 132-column summary of all major pools in the nutrient model. Note that in the column headings for this figure, the number (1) represents surface litter residue, and the number (2) represents the upper, active soil residue zone (approximately 200 mm). Definitions of the pool names can be found in appendix E. This sample output shows the effect of plowing in surface residue, as well as the effect of greater decay rates in the warmer months.

RUNNING OPUS

Opus is furnished for an IBM-compatible PC operating under DOS. The code is written in FORTRAN, so it can be furnished for compilation on a different operating system if desired. Opus is run by typing the word OPUS at the system prompt. Opus prompts for file names, both mandatory and optional, which must follow DOS naming convention. Opus executable code uses about 511kb of operating memory, which somewhat restricts the amount of other resident memory that can be taken by concurrent DOS applications.

Table 16 describes system input/output information that is necessary for running Opus. Mandatory files are always read or written. Optional files depend on certain input and output options, chosen by assigning flag values in the input parameter file (see "Opus Parameter File" section, group A). The access to these files is also indicated in figure 2.

The set of input and output files used in any run is retained as information in a file called OPUSAV.FIL. If such a file is found in the current directory, this file is read and the information is displayed during the interactive startup. This feature is intended to aid the user when making only parameter changes between runs. The resident file assignments can be accepted or can be replaced by the user at will.

Sample Run

The Opus DOS model is furnished with sample input and output files. The user should always implement the program by first running this sample simulation and should check that the results obtained are very similar to the output provided. Computers with various machine precisions will always produce slightly different results, but significant differences should be investigated.

Modifying Opus

The Opus FORTRAN code was not designed to be either read or modified by users. The system is extremely complex, and some functions are performed in certain subprograms for programming convenience, rather than in simple separate subroutines. Interactions are not always obvious, and most changes are not simple. Thus, modification can cause unexpected (and insidious) results.

Table 16.
System Input/Output Information

Device[1]	Occurrence	Function	Contents
1	Mandatory	Read only	Meteorologic data (climate statistics; rainfall data, if used)
2	Mandatory	Read only	Parameter data (watershed description; initial conditions; management data)
3	Mandatory	Write only	Printer-formatted output file (always written); contains some input data notes, run summary, and program error and warning messages; contains stormwise hydrologic data if requested.
4	Optional	Read only	Measured hydrology, meteorology, and/or sediment data, if available
7	Optional	Write only	Optional within-storm hydrologic output
8	Optional	Write only	Optional soil-layer output
9	Optional	Write only	Optional residue pool output or crop growth summary. Selection made by user at start of run.

[1]Device numbers (e.g., READ(1,...) and WRITE(3,...) are defined in main program in variables named INUNn and IOUTn, where n is the device number. All READ and WRITE statements reference the variable unit name, to allow simple changing of units on systems where our choice of numbers conflicts with system defaults.

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Appendix A. Programs to Convert CREAMS Precipitation Files to Opus Input Format

The same basic process is used to modify both daily and breakpoint data files: An old file is read, a small "additional data" file is read, and a new file is written. Table A-1 describes the structures and formats of the three files for each case.

Table A-1. CREAMS-Opus rain conversion program: Input and output files

Case	File	Logical Unit	Function	Record	Variables	Format
DAILY	Old format precip	1	Read	1-37*	R(I),I=1,10	(10x,10F5.2)
	Additional info	2	Read	1 2	ITITLE(I),I=1,20 IYR	(20A4) (I2)
	OPUS format	3	Written	1 2-38*	ITITLE(I),I=1,20 IYR,(R(I), I=1,10),N	(20A4) (3x,I2,5x, 10F5.2,I5)

* Repeated for each year's data.

Case	File	Logical Unit	Function	Record	Variables	Format
BREAKPOINT	Old format precip	1	Read	1	IYR,IDA,N	(3I8)
				2-*	R(1),T(I)	(2F8.2)
	Additional info	2	Read	1	ITITLE(I),I=1,20	(20A4)
	OPUS format	3	Written	1 2	ITITLE(I),I=1,20 IYR,IDA,N	(20A4) (3I8)
				3-*	(R(I),T(I),I=1,5)	(10F8.2)

* Repeated, 5 pairs per line, until all breakpoint pairs are written.

The following programs, DACNVT and BKNCVT, convert daily and breakpoint data from old CREAMS format to OPUS format:

```
--------------------------------------------------------------------------
c
        Program DACNVT
c
c       FORTRAN program to convert CREAMS DAILY precip files
c       to OPUS format
c                                    File Information
c                                Unit  Function  Contents
c                                ----  --------  ----------------------------
c                                 1     READ     Old CREAMS daily precip
c
c                                 2     READ     Title line and first year line
c
c                                 3     WRITE    New OPUS-formatted file
c
c --------------------------------------------------------------------------
c
       dimension ititle(20),r(10)
c
       read(2,200)(ititle(i),i=1,20)
       read(2,201)iyr
c
       write(3,200)(ititle(i),i=1,20)
 1     continue
c
       do 10 i=1,37
           read(1,100,end=99)(r(j),j=1,10)
           write(3,300)iyr,(r(j),j=1,10),i
 10    continue
c
       iyr = iyr+1
       go to 1
c
c end-of-file
c
 99    stop
c
 100   format(10x,10f5.2)
 200   format(20a4)
 201   format(i2)
 300   format(3x,i2,5x,10f5.2,i5)
c
       end
```

```
c
c
       Program BKCNVT
c
c
c      FORTRAN program to convert CREAMS BREAKPOINT precip files
c      to OPUS format
c
c                                    File Information
c                                Unit  Function  Contents
c                                ----  --------  ----------------------------
c                                 1      READ    Old CREAMS breakpoint precip
c
c                                 2      READ    Title line
c
c                                 3      WRITE   New OPUS-formatted file
c
c -----------------------------------------------------------------------------
c
      dimension ititle(20),r(200),t(200)
c
      read(2,200)(ititle(i),i=1,20)
      write(3,200)(ititle(i),i=1,20)
c
      write(3,201)
c
 1    read (1,100,end = 99)iyr,ida,n
      write(3,100)iyr,ida,n
c
      do 10 i=1,n
 10   read(1,101)(r(i),t(i))
c
      nc=1
c
c     rewrite five pairs per line
      j1=1
 15   j2=min0(5*nc,n)
      write(3,300)(r(i),t(i),i=j1,j2)
      if (j2.eq.n) go to 1
      j1 = j1+5
      nc = nc+1
      go to 15
c
c  end-of-file
 99   stop
c
 100  format(3i8)
 101  format(2f8.2)
 200  format(20a4)
 201  format('       1)
 300  format(10f8.2)
      end
```

Appendix B. Input Variable Glossary:

Part 1. Input Parameters

****
RUN ID AND CONTROL FLAGS
****

Record	Variable	Description	Units Metric	Units English	Default metric
A01	TITLE	(3 lines) Descriptive information			
A02	IBDATE	Simulation begin date		mmddyy	
A02	IEDATE	Simulation end date		mmddyy	
A02	IFWRDA	Controls writing of date to terminal throughout simulation 0 = no screen output 1 = date output			
A02	INTSP	Time increment of output to soil layer file 0 = no output 1 = daily 31 = last day of each month 365 = annual n = every n days		days	
A02	ICON	Flag switching soil layer output from mass to concentration for all chemical variables 0 = mass output 1 = concentration output			
A02	THRESH	Rainfall depth below which no detailed surface hydrology is output	mm	in	
A02	IRYR	Rotation year of run start (corresponds to input sequence in management list)			
A03	INUN	Tells Opus units of input data 1 = metric 2 = English			
A03	IOU	Output analog of INUN			
A03	IKOP	Specifies runoff methodology 1 = SCS curve number (daily values) 2 = infiltration model (breakpoint data)			
A03	IPAN	Pan evap/data flag 0 = Solar radiation data read 1 = pan evap data read			
A03	IFOUT	Controls output options 0 = Monthly and annual hydrology summary only 1 = Stormwise hydrology summary in addition to monthly and annual summaries			
A03	IFRAN	Controls meteorologic data randomization 0 = Temp and rad daily means (smooth) 1 = randomize T & R			
A03	IFRNCN	Controls randomization of curve number results 0 = no randomization 1 = results randomized			
A03	IFREAL	Real data file option 0 = no 1 = yes			
A04	IFSED	Sediment transport option 0 = no 1 = yes			
A04	IFNUT	Simulation of nutrient transport and soil nutrient transformations 0 = none 1 = nitrogen only 2 = nitrogen and phosphorus			
A04	IFPEST	Pesticide transport options 0 = none 1 = pesticides 2 = radionuclides			

Record	Variable	Description	Units Metric	Units English	Default metric
A04	IFIRR	Irrigation additions options 0 = none 1 = sprinkler 2 = local furrow 3 = ditch furrow			
A04	IFPOND	Farmpond unit option 0 = no 1 = yes, with depth-area relation input 2 = yes, with depth-area relation estimated from topography			
A04	IFDRAN	Tile drains option 0 = no 1 = yes			
A04	IVARK	Spatially varying USLE "K" option 0 = no 1 = yes			
A04	IFT	Actual mean monthly weather variables read 0 = no data furnished 1 = daily max and daily min temperatures 2 = daily mean radiation (Langleys)			
A04	IFGEN	Controls generating of daily rainfall data 0 = data not generated 1 = daily rainfall generated			

****

GENERAL WATERSHED & INITIAL STATE

****

Record	Variable	Description	Units Metric	Units English	Default metric
B01	DA	Field area	ha	ac	
B01	DWTB	Depth to water table, or drains if IFDRAN>0	m	ft	
B01	GLAT	Latitude of field (+=N hemisphere, -=S)	degrees	degrees	
B01	CN2	AMC Class II curve number (hydrology option IHOP=1)			
B01	PHRN	Rainfall pH	-	-	
B01	CONRN	Rainfall N concentration	mg/L	ppm	
B01	DASL	Depth of chemically interacting soil	mm	in	10
B01	ALBS	Smooth, dry soil surface albedo	-	-	0.35
B01	FWIND	Evap. enhancement factor wind and humid.(mean)	-	-	0.28
B02	SRESD	Initial surface residue amount	kg/ha	lb/ac	
B02	STDRY	Initial standing plant dry matter	kg/ha	lb/ac	
B02	THST	Initial soil water content (by volume)	mm/mm	in/in	
B02	ROWSP	Initial row spacing on field	m	ft	
B02	DPFR	Initial furrow depths, (mean)	cm	in	
B02	RGSURF	Initial relative surface roughness height	mm	in	
B02	ZSF	Initial row sideslope, as cotangent (H:V)	cm/cm	in/in	1.5
B02	DTILL	Initial depth to plowpan (optional)	cm	in	
B03	NC	Number of crops on field at start of simulation	-	-	
B03	ICR(I)	Crop ID no. for Ith crop on field at start of simulation (I=1 to NC) (ID no. corresponds to order in data D)	-	-	

Record	Variable	Description	Units Metric	English	Default metric
		******************** SOIL HORIZON DATA ********************			
C01	NSL	Number of distinct soil horizons (input)	-	-	
C02	GZH(I)	Depth from surface to bottom of horizon I	mm	in	
C02	POR(I)	Undisturbed porosity of horizon I (fraction by vol.)	mm/mm	in/in	
C02	PSAND(I)	Proportion by wt. sand-size particles in soil I	fraction		
C02	PSILT(I)	Proportion by wt. silt-size particles in soil I	fraction		
C02	PCLAY(I)	Proportion by wt. clay-size particles in soil I	fraction		
C02	RC(I)	Natural saturated hydraulic conductivity soil I	mm/hr	in/hr	
C02	B15(I)	15-bar water content of horizon I	mm/mm	in/in	
C02	PBUB(I)	Air entry potential of horizon I (Table 7)	mm	in	
C02	ALAM(I)	Pore-size distrbution index of hor. I	-	-	
C02	THS(I)	Soil water content at saturation	mm/mm	in/in	
C03	ORGC(I)	Organic C content of hor. I, % by wt.	%	%	
C03	SRSDU(I)	Initial incorporated plant residue in hor. I	g/t	ppm	
C03	WNO3(I)	Soil nitrate content of hor. I, soluble	g/t	ppm	
C03	WPLAB(I)	Soil labile P content of hor. I	g/t	ppm	
C03	SPH(I)	pH of horizon I	-	-	
C03	PKD(I)	Isothermal adsorption coefficient for labile P in layer I	mL/g	mL/g	100+2.5*PCLAY
C03	FEROD(I)	Flag indicating erosion resistance 0=erodible 1=nonerodible			
C03	OMN(I)	Organic matter N in layer I	g/t	ppm	
C03	OMP(I)	Organic matter P in layer I	g/t	ppm	
C03	TOTP(I)	Total phosphorus content of soil	kg/ha	lb/ac	50
		****************** CROP DATA ******************			
D01	NCROP	Total no. of different crops in rotation cycle	-	-	
D02	IDCR(I)	Identifying name for crop, 1 to 7 letters	-	-	
D02	IPER(J)	Annual-Perennial crop type identifier for crop J 0 = annual crop 1 = perennial, harvested 2 = perennial, grazed 3 = perennial, ungrazed 4 = annual, grazed 5 = winter annual			
D02	PLAI(J)	Maximum potential leaf area index, crop J	-	-	
D02	DDEM(J)	Degree-days to emergence of crop J	°C-days	°F-days	
D02	DDMX(J)	Degree-days to maturity of crop J	°C-days	°F-days	
D02	PDRYM(J)	Potential annual total dry matter production, crop J	kg/ha	lb/ac	
D02	POTY(J)	Potential yield of fruit or seed for crop J	kg/ha	lb/ac	
D02	RDP(J)	Potential max. root depth of crop J	mm	in	
D02	PLIG(J)	Plant above-ground lignin content	fraction		
D02	RLIG(J)	Plant root lignin content	fraction		
D03	POTHT(J)	Potential plant height for crop J	m	ft	
D03	PPCV(J)	Maximum relative surface coverage of crop J	-	-	
D03	TGBM(J)	Minimum temperature for growth of crop J	°C	°F	

Record	Variable	Description	Units Metric	English	Default metric
D03	TGOP(J)	Optimum temperature for growth of crop J	°C	°F	
D03	CONVF(J)	Coefficient of conversion of radiation to dry matter: photosynthetic constant for crop J	kg/ha/ly	-	
D03	DEACT(J)	Rate of loss of active leaf area during senescence	kg/kg/day	lb/lb/day	
D03	COVI(J)	Relative amount of winter shade from <u>perennial</u> dry matter (stems and all) for crop J	-	-	
D03	DMINIT(J)	Initial weight of plant if planted as a seedling (0 = seeded crop or perennial)	kg/ha	lb/ac	
D04	CONY(J)	N fraction in fruit or seed of plant J	kg/kg	lb/lb	
D04	CFXN(J)	Flag indicating crop J is an N-fixer 0 = no 1 = yes			
D04	PNO(J)	N in dry matter of plant J at emergence	kg/kg	lb/lb	
D04	PNF(J)	N in dry matter of plant J at maturity	kg/kg	lb/lb	
D04	DKC(J)	Decay coefficient for relative curvature of N concentration curve between PNO and PNF as plant grows, (0=straight line, 10=rapid decline)	-	-	
D04	PNRAT(J)	Ratio of P to N in plant J	-	-	

****

MANAGEMENT

****

Record	Variable	Description	Units Metric	English	Default metric
E01	THENTH	Relative moisture content above which no tillage or field operation is performed	mm/mm	in/in	
E02	NTL	Total number of different management field operations	-	-	
E03	IDTIL(J)	7-letter identification of field operation J	-	-	
E03	IDPL(J)	ID of crop with tillage J (same order as data D)	-	-	
E03	NTYTL	Code categorizing field operation into 1 of 5 types 1 = plant seeds 2 = cultivate 3 = harvest or grazing 4 = plow, incorporate standing dry 5 = plow, leave standing dry; or root harvest			
E03	RFT(J)	Random roughness produced on surface by field operation	mm	in	
E03	PLOWD(J)	Depth of penetration of operation J. Must be <GZH(1), depth of top horizon	mm	in	
E03	EFTL(J)	Mixing or harvest efficiency of operation J	fraction		
E03	DFRW(J)	Furrow depth produced by operation J	cm	in	
E03	WFRW(J)	Furrow spacing produced by operation J	m	ft	
E04	NPST	Number of different pesticides applied	-	-	
E05	IDPST(K)	7-letter identification name of pesticide K	-	-	
E05	DKFL(K)	Foliar decay coefficient, pesticide K	day^{-1}	day^{-1}	
E05	DKSOIL(K)	Decay coefficient for pesticide K in soil	day^{-1}	day^{-1}	
E05	DKOC(K)	K_{oc} (isothermal coefficient) for adsorption of pesticide K on soil	mL/g	-	
E05	PPWLF(K)	Current amount of washable pesticide K on plants (initializing data)	kg/ha	lb/ac	
E05	PINSLT	Starting amount of pesticide K in first 10 mm of soil	kg/ha	lb/ac	
E05	PSOLUB(K)	Water solubility of pesticide K	g/t	ppm	
E05	FWASH(K)	Fraction of pesticide K on plants that is washable	fraction		
E05	BEXTR(K)	Surface flow extraction coefficient for pesticide K	kg/L	-	
E05	RELP(K)	Relative rate factor for kinetic adsorption model	min^{-1}	min^{-1}	0.9

Record	Variable	Description	Units Metric	Units English	Default metric
E06	DKTHE(K)	Soil moisture at which DKSOIL determined	mm^3/mm^3	in^3/in^3	0.5
E06	DKTEMP(K)	Temperature at which DKSOIL determined	°C	°F	21
E06	ARRHC(K)	Activation energy for Arrhenius equation	Kcal/mole	-	10
E07	PLCON(K)	Initial concentration of pesticide K in layer ending at PLDEP	mg/kg	ppm	
E07	PLDEP(K)	Depth from surface to the bottom of the region where PLCON applies	mm	in	
E08	NMAN	No. of manure types defined by user (9 are intrinsic)	-	-	
E09	N	Index of manure type being read in	-	-	*
E09	ATN(N)	Nitrate content of manure type N	%	%	*
E09	ANH(N)	Ammonia content of manure N	%	%	*
E09	APHOS(N)	Labile P content of manure N	%	%	*
E09	AOM(N)	Organic matter content of manure N * Default values for 9 common types of land-applied manure are provided, described in Table 10	%	%	*
E10	NYROT	Number of years in rotation cycle	-	-	
E11	NTY(Y)	No. of mechanical operations in rotation yr Y	-	-	
E12	MO	Month of this operation	month		
E12	IDA	Day of this operation	day of month		
E12	KTILL(Y,I)	Code no. of this (Ith) operation (corresponding to order of input in E04 list)	-	-	
E13	NFR(Y)	No. of fertilizer applications in rotation yr Y	-	-	
E14	MO	Month of fertilization N	month		
E14	IDA	Day of this operation	day of month		
E14	KAPPL(Y,N)	Code of method of fertilization in rotation yr Y 0 = surface applied 1 = inject into soil 2 = dissolved in irrigation water			
E14	FERN(Y,N)	Nitrate in Nth fertilization in yr Y	kg/ha	lb/ac	
E14	FERP(Y,N)	Phosphate in Nth fertilization in yr Y	kg/ha	lb/ac	
E14	FERA(Y,N)	Ammonia in Nth fertilization in yr Y	kg/ha	lb/ac	
E14	MATYP(Y,N)	Code of manure type in Nth application (0=none, 1-10 default or user-supplied types)	-	-	
E14	RATE(Y,N)	Manure application rate in Nth applic. in yr Y	t/ha	tn/ac	
E14	DEPIN(Y,N)	Depth of injection, if added at a single depth	mm	in	
E15	NPEST(Y)	No. of pesticide applications in rotation yr Y	-	-	
E16	MO	Month of application P	month		
E16	IDA	Day of application P	day of month		
E16	KPEST(Y,P)	Type code of Pth applic. in yr Y (corresponding to E06 cards)	-	-	
E16	IAPLIC(Y,P)	Code of application method for applic. P 0 = inject into soil 1 = aerial application, specific division between amt. landing on soil & plant 2 = dissolve in irrigation water 3 = aerial application, program decides amt. landing on soil & plant			
E16	QPEST(Y,P)	Amount of pesticide in Pth application	kg/ha	lb/ac	
E16	FRACA(Y,P)	Proportion of QPEST lost offsite (e.g. evaporation)	fraction		
E16	FRACP(Y,P)	Proportion of QPEST intercepted by plant, if known	fraction		
E16	DEPST(Y,P)	Depth of injection, if so applied	mm	in	
E17	IRRDY	No. of days in irrigation season	-	-	

Record	Variable	Description	Units Metric	English	metric	Default
E17	IMOS	Month of irrigation start	month			
E17	IDAS	Day of irrigation start	day of month			
E17	NIRD	Interval of days between regular-schedule irrigation	days	days		
E17	AMIRR	Depth of irrigation per event	mm	in		
E17	TIRR	Total annual supply for ditch-type irrigation	mm	in		
E17	THIRR	Soil water content threshold below which irrigation is performed (demand scheduling)	mm/mm	in/in		
E17	QIRR	Rate of application into basic field unit	m^3/s	ft^3/s		
E18	DRSP	Horizontal spacing of draintiles	m	ft		
E18	DDIMP	Depth below drains to limiting/imperv. boundary	m	ft		
E18	RCLM	Mean flux limit of lower bound at DDIMP	mm/hr	in/hr		
		************************ FIELD TOPOLOGY ************************				
F01	IFFIX	Flag indicating presence of a fixed-management zone along the 'overland' (plane of furrow) flow path 0 = no 1 = yes				
F01	ITOCH	Second order channel option 0 = no 1 = yes				
F01	MULP(K)	No. of (identical) runoff segments contributing to the order 1 channel(s) 1 = channel is on one edge, 2 = channel is between two segments				
F01	XLP	Length of mean flow path on surface or along furrow for runoff segment	m	ft		
F01	SLA(KL,1)	Mean overall slope along path XLP	m/m	ft/ft		
F01	PAR	Total area feeding order 1 channel. Includes both elementary segments if MULP = 2	ha	ac		
F01	PMN	Initial Manning's n for plane				
F02	NPT	No. of locations along XLP at which slope is specified. For J=1 to NPT:	-	-		
F03	XSP(J)	Distance along path XLP at which slope SP(J) is measured	m	ft		
F03	SP(J)	Local slope at location XSP(J)	m/m	ft/ft		
F04	XLFS	Distance from top of slope to beginning of fixed zone (such as grass buffer zone)	m	ft		
F04	XLFE	Distance from top of slope to end of fixed management zone	m	ft		
F04	RMNF(KL,L)	Fixed value of Manning n in unmanaged zone	-	-		
F04	SLRF	Fixed value of "soil loss ratio" in unmanaged zone	-	-		
F04	PRFF	Fixed value of USLE "P-factor" in unmanaged zone	-	-		
F05	NKP	No. of different zones of USLE K along XLP	-	-		
F06	XKS(J)	Distance along XLP to lower end of zone having soil with USLE K of USK(J)	m	ft		
F06	USK(J)	USLE 'K' for zone from XKS(J-1) to XKS(J) * units are complicated, see text	*	*		
F07	IFFIX	Flag indicating presence of fixed management zone along the channel path 0 = no 1 = yes				

Record	Variable	Description	Units Metric	Units English	Default metric
F07	NUN(KL)	Number of order L-1 catchments (of area PAR) making up order L catchment, or total field	-	-	
F07	NEPH(KL,L)	Flag indicating channel permanence 0 = permanent 1 = ephemeral (reset by cultivation)			
F07	XLC	Length of flow along channel path	m	ft	
F07	SLA(KL,L)	Mean overall slope along XLC	m/m	ft/ft	
F07	ZCA(KL,L)	Mean initial channel sideslope (H:V)	m/m	ft/ft	
F07	ARUP(KL,L)	Area (fraction of PAR) contributing to upstream point along XLP at which defined channel begins	ha	ac	
F07	WINIT	Initial width of channel bottom width at channel outlet (0 indicates triangular section, negative indicates a naturally eroded rectangular section with width = |WINIT|)			
F07	DINIT	Initial depth of channel below mean surface	m	ft	
F07	PMN	Manning's n for channel			
F08	NPT	No. of locations along path XLC at which a varying local slope is specified	-	-	
F09	XSP(J)	Distance along path XLC at which slope SP(J) is given	m	ft	
F09	SP(J)	Local slope at location XSP(J)	m/m	ft/ft	
F10	XLFS	Distance from top of XLC to start of fixed condition section	m	ft	
F10	XLFE	Distance from top of XLC to end of fixed section (e.g. grass-lined channel section)	m	ft	
F10	RMNF(KL,L)	Manning n roughness of fixed section	-	-	
F10	TAUCF(KL,L)	Critical shear for hydraulic erosion	N/m^2	lbf/ft^2	
F10	WIDFX(L)	Width of channel thru the unmanaged or lined section	m	ft	
F11	IFOUTL	Flag for pond outlet rating 1 = rating from power function (see below) 2 = rating from orifice diameter = CQ			
F11	AV	Parameters in relation of surface area, AS,	m^2	ft^2	
F11	BV	to its depth, h, for farm pond:	*	*	
F11	CV	$AS = AV + BV * (h)^{CV}$			
F11	CQ	Parameters in relation to outflow discharge, QO,	m^3/min	ft^3/min	
F11	EQ	to depth, h, for farm pond:			
F11	ZQ	$QO = CQ(h - ZQ)^{EQ}$ OR: Note: IFOUTL = 2 indicates that CQ = orifice diameter (mm or in), in which case EQ and ZQ may be blank	mm	in	
F11	RLOSS	Rate of loss from pond bottom	mm/hr	in/hr	

****

EROSION/SEDIMENT

****

Record	Variable	Description	Units Metric	Units English	Default metric
G01	NPS	No. of particle size classes	-	-	
G02	DPS(J)	Mean effective diameter of particle size class J	mm	in	
G02	RHOP(J)	Effective particle specific gravity for size class J	-	-	2.65
G02	PROSL(J)	Proportion of particles by wt. in size class J	fraction		
G02	FRASN(J)	Fract. of particle class J made of primary sand	fraction		
G02	FRASL(J)	Fract. of particle class J made of primary silt	fraction		
G02	FRACL(J)	Fract. of particle class J made of primary clay	fraction		
G02	FRORG(J)	Fract. of particle class J of organic matter	fraction		

Record	Variable	Description	Metric	Units English	metric	Default
G03	SSCLY	Specific surface of clay-size particles		m^2/m^3	ft^2/ft^3	20.0
G03	SSSLT	Specific surface of silt-size particles		m^2/m^3	ft^2/ft^3	4.0
G03	SSSND	Specific surface of sand-size particles		m^2/m^3	ft^2/ft^3	0.05
G03	SSORG	Effective specific surface of soil organic matter		m^2/m^3	ft^2/ft^3	1000
G04	ASLK	USLE K for overall field soil(s)		*	*	
G04	PRF	USLE P-factor for cropping practice option 1 only		-	-	
G04	EKT(1)	Relative erodibility factor for splash erosion on		**	**	0.08679 plane
G04	EKT(2)	Critical shear initiating erosion in channel 1		N/m^2	lbf/ft^2	***
G04	EKT(3)	Critical shear initiating erosion in channel 2		N/m^2	lbf/ft^2	

* units are complicated, see text

** English EKT units are roughly sec/(ft*32). Metric = English * 0.0844

*** defaults for EKT(2) and (3) are: 0.246* Metric USLK (unfurrowed, plane)

Appendix B. Input Variable Glossary:

Part 2. Meteorological Data

****

METEOROLOGICAL DATA

****

Record	Variable	Description	Units Metric	Units English	Default Metric
H01	DATNAM	Identifying information at start of data file	-	-	
H02	TXMD	Mean dry-day maximum temperature	°C	°F	
H02	ATX	Amplitude of annual variation of TXMD	C°	F°	
H02	CVTX	Coefficient of variation of maximum T on dry days	C°/°C	F°/°F	
H02	ACVTX	Amplitude of annual variation of CVTX (in phase with TXMD)	C°/°C	F°/°F	
H02	TXMW	Mean wet-day maximum temperature	°C	°F	
H03	TN	Mean dry-day minimum temperature	°C	°F	
H03	AMTN	Amplitude of annual variation of TN	C°	F°	
H03	CVTN	Coefficient of variation of minimum temperature	C°/°C	F°/°F	
H03	ACVTN	Amplitude of annual variation of CVTN	C°/°C	F°/°F	
H04	RMD	Annual mean daily net radiation on dry days	ly	ly	
H04	AR	Amplitude of annual variation of RMD	ly	ly	
H04	RMW	Annual mean daily net radiation on wet days	ly	ly	
H04	SEED	Random number generator seed	-	-	231
H05	PRW(2,M)	Probability of a wet day following a wet day for month M	decimal		
H06	PRW(1,M)	Probability of a wet day following a dry day for month M	decimal		
H07	ALFG(M)	Gamma distribution parameter for statistical description of daily rainfall amount on wet days in month M	-	-	
H08	BETG(M)	Gamma distribution parameter for statistical description of daily rainfall depth on wet days in month M	mm	in	
H09	RI(M)	Relative peak 30-min rain intensity (from record) for month M	mm/hr	in/hr	
H10	TAMX(M)	Mean daily maximum temperature for month M	°C	°F	
H11	TAMN(M)	Mean daily minimum temperature for month M	°C	°F	
H12	RA(M)	Mean daily incoming solar radiation for month M	ly	ly	
H13	TP05	30-min. rain depth with 10-yr return period	mm	in	
H13	TP6	6-hr. rain depth with 10-yr return period	mm	in	
H13	COEFF	Pan coefficient, value needed if IFPAN>0	-	-	

Appendix C. Sample Parameter and Meteorology File Templates

1. The Parameter File Template begins with the line "O P U S ..":

```
                         O P U S  Parameter File Template
                        ===================================
  Enter data on lines ending with record ID in col. 78-80 (e.g. A01)

  See Opus User Manual for detailed description of input data.

  Variable name is printed above its location: enter data right-justified to
  the variable name.

  The record ID must be in columns 78-80 of all data input records;  be sure
  this is accomplished when entering data on template.

  Data type (A-I) in column 78 corresponds to User Manual data type and
  chapter; e.g. guidance for the management record set will be found in the
  User Manual on pages noted "Group E - Management" above the page number.

*****************************************************
*****************************************************
**                                                 **
**  R U N   I D   and   C O N T R O L   F L A G S **
**                                                 **
*****************************************************
*****************************************************

 TITLE :  Enter 3 lines of descriptive info to identify this simulation
WATKINSVILLE, GA., Catchment P-3     EPA management data                     A01
                                                                             A01
73-75(length of precip record)       Breakpoint run                          A01
   ------------------------------------------------------
      Enter run begin and end dates and run option flags
   ------------------------------------------------------
IBDATE IEDATE
MODAYR MODAYR IFWRDA  INTSP   ICON THRESH   IRYR
050173 060474      1     30      0   1.33      1                             A02
  INUN    IOU   IHOP   IPAN  IFOUT  IFRAN IFRNCN IFREAL
     2      1      2      0      2      1      0      0                      A03
 IFSED  IFNUT IFPEST  IFIRR IFPOND IFDRAN  IVARK    IFT  IFGEN
     2      1      1      0      1      0      0      2      0               A04

 ***************************************************************************
 ***************************************************************************
 **                                                                       **
 **  G E N E R A L    W A T E R S H E D  &  I N I T I A L   S T A T E **
 **                                                                       **
 ***************************************************************************
 ***************************************************************************

    DA   DWTB   GLAT    CN2   PHRN  CONRN   DASL   ALBS  FWIND
  3.11   10.0   31.0    80.   5.60   0.80   0.39   0.35   0.28               B01
 SRESD  STDRY   THST  ROWSP   DPFR RGSURF    ZSF  DTILL
 100.0  100.0   0.20    0.5    3.0    0.5    0.5     0.                      B02
 ---------------------------------------
  There must be NC values of ICR on B03
 ---------------------------------------
    NC    ICR    ICR    ICR    ICR
     1      1                                                                B03
```

```
*****************************************************************
*****************************************************************
**                                                             **
**              S O I L    H O R I Z O N   D A T A             **
**                                                             **
*****************************************************************
*****************************************************************
  NSL
    4                                                                     C01
 -----------------------------------------
  There must be NSL sets of C02-C03 prompts
  and records, one for each horizon
 -----------------------------------------
   GZH     POR   PSAND   PSILT   PCLAY      RC     B15    PBUB    ALAM     THS
  6.00     .41     .64     .19     .17    0.55     .13     4.9    -1.0     .33    C02
  ORGC   SRSDU    WNO3   WPLAB     SPH     PKD   FEROD     OMN     OMP    TOTP
  1.00    100.   250.0    22.0     5.9    -1.0    0.00    -1.0    -1.0    -1.0    C03
   GZH     POR   PSAND   PSILT   PCLAY      RC     B15    PBUB    ALAM     THS
  12.0     .45     .49     .14     .37    0.30     .24     5.0    -1.0     .35    C02
  ORGC   SRSDU    WNO3   WPLAB     SPH     PKD   FEROD     OMN     OMP    TOTP
   .30     50.   200.0    12.0     6.0    -1.0     0.0    -1.0    -1.0    -1.0    C03
   GZH     POR   PSAND   PSILT   PCLAY      RC     B15    PBUB    ALAM     THS
  24.0     .49     .46     .16     .38    -1.0     .28       0    -1.0     .40    C02
  ORGC   SRSDU    WNO3   WPLAB     SPH     PKD   FEROD     OMN     OMP    TOTP
   .15     20.    50.0     1.0     6.0    -1.0     0.0    -1.0    -1.0    -1.0    C03
   GZH     POR   PSAND   PSILT   PCLAY      RC     B15    PBUB    ALAM     THS
  60.0     .49     .51     .27     .22    -1.0     .28       0    -1.0     .45    C02
  ORGC   SRSDU    WNO3   WPLAB     SPH     PKD   FEROD     OMN     OMP    TOTP
   .05      2.     20.     1.0     6.0    -1.0     0.0    -1.0    -1.0    -1.0    C03

*********************************************************
*********************************************************
**                                                     **
**           C R O P        D A T A                    **
**                                                     **
*********************************************************
*********************************************************
 NCROP
    3                                                                     D01
 -------------------------------------
  There must be NCROP sets of D02-D04
  prompts and data records
 -------------------------------------
    IDCR    IPER    PLAI    DDEM    DDMX   PDRYM    POTY     RDP    PLIG    RLIG
 win.rye       0    3.00   150.0   2500.   4000.     48.    24.0    0.15    0.10   D02
   POTHT    PPCV    TGBM    TGOP   CONVF   DEACT    COVI  DMINIT
     2.0    0.80    35.0    80.0    25.0    0.02     0.0     0.0                   D03
    CONY    CFXN     PNO     PNF     DKC   PNRAT
   0.018     0.0    0.02   0.012    3.50    0.25                                   D04
    IDCR    IPER    PLAI    DDEM    DDMX   PDRYM    POTY     RDP    PLIG    RLIG
 soybean       0    4.00   150.0   3600.   9000.   2300.    24.0    0.15    0.10   D02
   POTHT    PPCV    TGBM    TGOP   CONVF   DEACT    COVI  DMINIT
     4.0    0.60    40.0    90.0    20.0    0.02     0.0     0.0                   D03
    CONY    CFXN     PNO     PNF     DKC   PNRAT
   0.065     1.0    0.04   0.018    3.50    0.25                                   D04
    IDCR    IPER    PLAI    DDEM    DDMX   PDRYM    POTY     RDP    PLIG    RLIG
  Barley       0    3.00   150.0   3500.   6000.    480.    24.0    0.15    0.10   D02
   POTHT    PPCV    TGBM    TGOP   CONVF   DEACT    COVI  DMINIT
     3.0    0.80    35.0    80.0    25.0    0.02     0.0     0.0                   D03
```

```
  CONY    CFXN     PNO     PNF     DKC  PNRAT
 0.023     0.0    0.05   0.012    3.50   0.25                                D04
****************************************
****************************************
**                                    **
**      M  A  N  A  G  E  M  E  N  T  **
**                                    **
****************************************
****************************************
THEMTH
   .90                                                                       E01
   NTL
    11                                                                       E02
----------------------------------------
 There must be NTL E03 prompts and records
  (one blank set if NTL=0)
----------------------------------------
  IDTIL    IDPL  NTYTL     RFT  PLOWD    EFTL   DFRW    WFRW
plntrye       1      1    -.20    0.0    0.10   -1.0    0.50                 E03
  IDTIL    IDPL  NTYTL     RFT  PLOWD    EFTL   DFRW    WFRW
drilrye       1      2     .50    2.0    0.10   -1.0    0.50                 E03
  IDTIL    IDPL  NTYTL     RFT  PLOWD    EFTL   DFRW    WFRW
plntsoy       2      1    0.80    3.0    0.70    8.0    3.00                 E03
  IDTIL    IDPL  NTYTL     RFT  PLOWD    EFTL   DFRW    WFRW
pltbarl       3      1    1.00    2.0    0.30    3.0    0.50                 E03
  IDTIL    IDPL  NTYTL     RFT  PLOWD    EFTL   DFRW    WFRW
rolcult       0      2    0.50    2.0    0.70    4.0    3.00                 E03
  IDTIL    IDPL  NTYTL     RFT  PLOWD    EFTL   DFRW    WFRW
  sweep       0      2    0.50    2.0    0.70   -1.0    3.00                 E03
  IDTIL    IDPL  NTYTL     RFT  PLOWD    EFTL   DFRW    WFRW
DISK hr       0      4    1.50    4.0    0.50    1.0    0.50                 E03
  IDTIL    IDPL  NTYTL     RFT  PLOWD    EFTL   DFRW    WFRW
 cultiv       0      4    0.73    4.0    0.70    5.0    3.00                 E03
  IDTIL    IDPL  NTYTL     RFT  PLOWD    EFTL   DFRW    WFRW
hvst ry       1      3    0.24    0.0    0.90   -0.1    0.50                 E03
  IDTIL    IDPL  NTYTL     RFT  PLOWD    EFTL   DFRW    WFRW
hvst sy       2      3    0.24    0.0     0.0   -0.1    3.00                 E03
  IDTIL    IDPL  NTYTL     RFT  PLOWD    EFTL   DFRW    WFRW
hvst bl       3      3    0.24    0.0    0.90   -0.1    0.50                 E03
   NPST
      3                                                                      E04
------------------------------------------------------
  There must be NPST sets of E05-E07 prompts and records
  (one blank set if NPST=0)
------------------------------------------------------
  IDPST    DKFL DKSOIL    DKOC  PPWLF PINSLT PSOLUB   FWASH  BEXTR   RELP
TRIFLUR    .347  0.040    600.    0.0   0.12    1.0     0.0   0.03  0.000    E05
  DKTHE  DKTEMP  ARRHC
      0       0      0                                                       E06
  PLCON   PLDEP  PLCON   PLDEP  PLCON  PLDEP  PLCON   PLDEP  PLCON  PLDEP
  0.029    0.39  0.028     2.0  0.022    3.2  0.003     8.8                  E07
  IDPST    DKFL DKSOIL    DKOC  PPWLF PINSLT PSOLUB   FWASH  BEXTR   RELP
  PARAQ    .231  .0015   1.6E7    0.0   5.50  5.E05     0.0   0.03  0.000    E05
  DKTHE  DKTEMP  ARRHC
      0       0      0                                                       E06
  PLCON   PLDEP  PLCON   PLDEP  PLCON  PLDEP  PLCON   PLDEP  PLCON  PLDEP
    8.2    0.39    7.1     2.0    5.0    2.8    0.8     6.0                  E07
  IDPST    DKFL DKSOIL    DKOC  PPWLF PINSLT PSOLUB   FWASH  BEXTR   RELP
DIPHENA    .078   0.10    400.    0.0   1.00   260.     0.0   0.03  0.000    E05
```

```
DKTHE DKTEMP  ARRHC
    0      0      0                                                              E06
PLCON  PLDEP  PLCON  PLDEP  PLCON  PLDEP  PLCON  PLDEP  PLCON  PLDEP
0.012   0.39  0.009    1.0  0.006    2.0  0.010    3.0  0.001    6.0             E07
 NMAN
    0                                                                            E08
 ------------------------------------------------------------------------------
 There must be NMAN sets of E09 prompts and records (one blank set if NMAN=0)
 ------------------------------------------------------------------------------
     N     ATN     ANH   APHOS    AOM
                                                                                 E09
NYROT
    3                                                                            E10
 ++++++++++++++++++++++++++++++++++++++++++++++++++++++
           R O T A T I O N   S C H E D U L E
            There must be NYROT sets of
            E11-E17 prompts and records
 ++++++++++++++++++++++++++++++++++++++++++++++++++++++
  NTY
    6         1973                                                               E11
 ------------------------------------------------------------------------------
 There must be NTY sets of E12 prompts and records (one blank set if NTY=0)
 ------------------------------------------------------------------------------
MO IDA  KTILL
 4  12      9                                                                    E12
MO IDA  KTILL
 5  22      7                                                                    E12
MO IDA  KTILL
 6  04      5                                                                    E12
MO IDA  KTILL
 6  15      3                                                                    E12
MO IDA  KTILL
10  05      1                                                                    E12
MO IDA  KTILL
11   7     10                                                                    E12
  NFR
    2                                                                            E13
 ------------------------------------------------------------------------------
 There must be NFR sets of E14 prompts and records (one blank set if NFR=0)
 ------------------------------------------------------------------------------
MO IDA  KAPPL   FERN   FERP   FERA  MATYP   RATE  DEPIN
 5  22      0    9.4   17.2    9.4      0      0                                 E14
MO IDA  KAPPL   FERN   FERP   FERA  MATYP   RATE  DEPIN
 6  04      0   11.1   19.6   11.1      0      0                                 E14
NPEST
    3                                                                            E15
 ------------------------------------------------------------------------------
There must be NPEST sets of E16 prompts and records (one blank set if NPEST=0)
 ------------------------------------------------------------------------------
MO IDA  KPEST IAPLIC  QPEST  FRACA  FRACP  DEPST
 6  14      1      0   0.50    0.0    0.0    0.0                                 E16
MO IDA  KPEST IAPLIC  QPEST  FRACA  FRACP  DEPST
 6  14      2      0   1.37    0.0    0.0    0.0                                 E16
MO IDA  KPEST IAPLIC  QPEST  FRACA  FRACP  DEPST
 6  14      3      0   3.00    0.0    0.0    0.0                                 E16
 ------------------------------------------------
 E17 can be blank if no irrigation (IFIRR on A04 is 0)
 ------------------------------------------------
 IRRDY MO IDA  NIRD  AMIRR  TIRR  THIRR  QIRR
```

```
                                                                    E17
     NTY
      10        1974                                                E11
    ---------------------------------------------------------------
    There must be NTY sets of E12 prompts and records (one blank set if NTY=0)
    ---------------------------------------------------------------
MO IDA  KTILL
 1  14      2                                                       E12
MO IDA  KTILL
 5   1      9                                                       E12
MO IDA  KTILL
 5  22      7                                                       E12
MO IDA  KTILL
 5  28      5                                                       E12
MO IDA  KTILL
 5  30      3                                                       E12
MO IDA  KTILL
 6  13      5                                                       E12
MO IDA  KTILL
 7   5      5                                                       E12
MO IDA  KTILL
10  18     10                                                       E12
MO IDA  KTILL
10  22      7                                                       E12
MO IDA  KTILL
10  22      4                                                       E12
   NFR
     1                                                              E13
   ---------------------------------------------------------------
   There must be NFR sets of E14 prompts and records (one blank set if NFR=0)
   ---------------------------------------------------------------
MO IDA  KAPPL   FERN   FERP   FERA  MATYP   RATE  DEPIN
 5  22      0    7.6   13.4    7.6      0      0                    E14
 NPEST
     3                                                              E15
-----------------------------------------------------------------
There must be NPEST sets of E16 prompts and records (one blank set if NPEST=0)
-----------------------------------------------------------------
MO IDA  KPEST IAPLIC  QPEST  FRACA  FRACP  DEPST
 5  29      1      0   0.50    0.0    0.0    0.0                    E16
MO IDA  KPEST IAPLIC  QPEST  FRACA  FRACP  DEPST
 5  29      2      0   1.37    0.0    0.0    0.0                    E16
MO IDA  KPEST IAPLIC  QPEST  FRACA  FRACP  DEPST
 5  29      3      0   3.00    0.0    0.0    0.0                    E16
 ----------------------------------------------
 E17 can be blank if no irrigation (IFIRR on A04 is 0)
 ----------------------------------------------
 IRRDY MO  DA   NIRD  AMIRR   TIRR  THIRR   QIRR
                                                                    E17
   NTY
     6     1975                                                     E11
    ---------------------------------------------------------------
    There must be NTY sets of E12 prompts and records (one blank set if NTY=0)
    ---------------------------------------------------------------
MO IDA  KTILL
 4  15     11                                                       E12
MO IDA  KTILL
 5  13      7                                                       E12
MO IDA  KTILL
```

```
  5  28      3                                                               E12
MO  IDA  KTILL
  6  16      6                                                               E12
MO  IDA  KTILL
  7   9      6                                                               E12
MO  IDA  KTILL
 11   5     10                                                               E12
    NFR
      1                                                                      E13
  -----------------------------------------------------------------------
  There must be NFR sets of E14 prompts and records (one blank set if NFR=0)
  -----------------------------------------------------------------------
MO IDA  KAPPL   FERN   FERP   FERA  MATYP   RATE  DEPIN
 5   8      0    0.0   13.4    0.0      0      0                             E14
 NPEST
     3                                                                       E15
--------------------------------------------------------------------------
There must be NPEST sets of E16 prompts and records (one blank set if NPEST=0)
--------------------------------------------------------------------------
MO IDA  KPEST IAPLIC  QPEST  FRACA  FRACP  DEPST
 5  27      1      0   0.50    0.0    0.0    0.0                             E16
MO IDA  KPEST IAPLIC  QPEST  FRACA  FRACP  DEPST
 5  27      2      0   1.37    0.0    0.0    0.0                             E16
MO IDA  KPEST IAPLIC  QPEST  FRACA  FRACP  DEPST
 5  27      3      0   3.00    0.0    0.0    0.0                             E16
  ----------------------------------------------------
  E17 can be blank if no irrigation (IFIRR on A04 is 0)
  ----------------------------------------------------
  IRRDY MO IDA   NIRD  AMIRR   TIRR  THIRR   QIRR
                                                                             E17
  -----------------------------------------------------------------------
    If IFDRAN on C04 is 1, enter draintile data; otherwise zeroes or blank:
  -----------------------------------------------------------------------
   DRSP  DDIMP   RCLM
   10.0   10.0   0.02                                                        E18
**************************************************
**************************************************
**                                              **
**           F I E L D   T O P O L O G Y        **
**                                              **
**************************************************
**************************************************
 ----------------------------------------
 The following F01-F10 set describes the
 natural, unfurrowed topology (KL=1)
 ----------------------------------------
  IFFIX  ITOCH   MULP    XLP    SLA    PAR    PMN
      0      1      1   86.0  0.030  0.518                                   F01
    NPT
      1                                                                      F02
 ------------------------------------------------
 There must be NPT pairs of XSP SP values
 If NPT>5, add a duplicate F03 prompt and record
 ------------------------------------------------
    XSP     SP    XSP     SP    XSP     SP    XSP     SP    XSP     SP
   1.00   0.03                                                               F03
   XLFS   XLFE   RMNF   SLRF   PRFF
                                                                             F04
```

```
    NKP
      0                                                                                  F05
---------------------------------------------
There must be NKP pairs of XKS USK values
If NKP> 5, add a duplicate F06 prompt and record
---------------------------------------------
    XKS     USK     XKS     USK     XKS     USK     XKS     USK     XKS     USK
   100.    0.24    150.    0.40                                                      F06
  IFFIX     NUN    NEPH     XLC     SLA     ZCA    ARUP   WINIT   DINIT     PMN
      0       6       0   262.0   0.005    20.0                                      F07
    NPT
      1                                                                              F08
---------------------------------------------
There must be NPT pairs of XSP SP values
If NPT>5, add a duplicate F09 prompt and record
---------------------------------------------
    XSP      SP     XSP      SP     XSP      SP     XSP      SP     XSP      SP
   1.00   0.005                                                                      F09
   XLFS    XLFE    RMNF   TAUCF    SLRF    PRFF
                                                                                     F10
  IFFIX     NUN    NEPH     XLC     SLA     ZCA    ARUP   WINIT   DINIT     PMN
      1       1       0   172.0    0.03    15.0                                      F07
    NPT
      1                                                                              F08
---------------------------------------------
There must be NPT pairs of XSP SP values
If NPT>5, add a duplicate F09 prompt and record
---------------------------------------------
    XSP      SP     XSP      SP     XSP      SP     XSP      SP     XSP      SP
   1.00   0.030                                                                      F09
   XLFS    XLFE    RMNF   TAUCF   WIDFX
    0.0   172.0    0.24     9.5     0.1                                              F10
--------------------------------------------------------------------------
The following F01-F10 set describes the furrowed case (KL=2); blanks or dummy
values are sufficient if there is no furrowed case (NTL   2 and DPFR = 0.0)
--------------------------------------------------------------------------
  IFFIX   ITOCH    MULP     XLP     SLA     PAR     PMN
      0       0       2   262.0   0.005   3.110    0.03                              F01
    NPT
      1                                                                              F02
---------------------------------------------
There must be NPT pairs of XSP SP values
If NPT>5, add a duplicate F03 prompt and record
---------------------------------------------
    XSP      SP     XSP      SP     XSP      SP     XSP      SP     XSP      SP
   1.00   0.005                                                                      F03
   XLFS    XLFE    RMNF    SLRF    PRFF
                                                                                     F04
    NKP
      0                                                                              F05
---------------------------------------------
There must be NKP pairs of XKS USK values
If NKP>5, add a duplicate F06 prompt and record
---------------------------------------------
    XKS     USK     XKS     USK     XKS     USK     XKS     USK     XKS     USK
   100.    0.24    150.    0.40                                                      F06
  IFFIX     NUN    NEPH     XLC     SLA     ZCA    ARUP   WINIT   DINIT     PMN
      1       1       1   258.0   0.030    15.0                                      F07
```

```
    NPT
      1
 -------------------------------------------------                      F08
 There must be NPT pairs of XSP SP values
 If NPT>5, add a duplicate F09 prompt and record
 -------------------------------------------------
   XSP     SP     XSP     SP     XSP     SP     XSP     SP     XSP     SP
  1.00   0.030
  XLFS    XLFE    RMNF   TAUCF   WIDFX                                    F09
  86.0   258.0     .24    9.5     0.1
 ------------------------------------------------------------------      F10
   If IFPOND  on A04 is 1 enter pond data; otherwise zeroes or blank:
 ------------------------------------------------------------------
 IFOUTL     AV     BV     CV     CQ     EQ     ZQ   RLOSS
      1   15.0 2000.0    2.0   2.41   2.05    0.0    0.1                  F11
*******************************************************
*******************************************************
**                                                   **
**            E R O S I O N/ S E D I M E N T         **
**                                                   **
*******************************************************
*******************************************************
    NPS
      0
 ------------------------------------------------------------            G01
 There must be NPS G03 prompts and records
 ------------------------------------------------------------
    DPS    RHOP   PROSL   FRASN   FRASL   FRACL   FRORG
   .002    2.60   0.04     0.0     0.0     1.0     0.0                   G02
  SSCLY   SSSLT   SSSND   SSORG
    0.0                                                                  G03
   ASLK     PRF    EKT1    EKT2    EKT3
   0.32    0.90    0.12   0.135   -1.0                                   G04
```

2. The following illustrates the Opus meteorology file template. The first line of the data file is the first line of asterisks below.

```
************************************************
************************************************
**                                            **
**  M E T E O R O L O G I C A L    D A T A    **
**                                            **
************************************************
************************************************
 TITLE : Enter one line of identifying information
Daily data 6/72-9/75, WATKINSVILLE P3                                               H01
 TXMD   ATX  CVTX ACVTX  TXMW
 73.0  18.0  0.11 -.075  71.5                         TEMP GEN PARS                 H02
   TN  AMTN  CVTN ACVTN
 51.5  18.5  0.16  -.13                                                             H03
  RMD    AR   RMW  SEED
450.0 175.0 269.0   0.0                                     RAD GEN PARS            H04
 PRW2  PRW2  PRW2  PRW2  PRW2  PRW2  PRW2  PRW2  PRW2  PRW2  PRW2  PRW2
0.502 0.490 0.433 0.426 0.462 0.473 0.548 0.437 0.490 0.561 0.385 0.469             H05
 PRW1  PRW1  PRW1  PRW1  PRW1  PRW1  PRW1  PRW1  PRW1  PRW1  PRW1  PRW1
0.261 0.291 0.286 0.247 0.188 0.258 0.318 0.208 0.163 0.119 0.207 0.258             H06
 -------------------------------------------
    The monthly ALFG and BETG values may be
    blank if daily rainfall is not being
    generated (IFRBY on record A03 is not 2)
 -------------------------------------------
 ALFG  ALFG  ALFG  ALFG  ALFG  ALFG  ALFG  ALFG  ALFG  ALFG  ALFG  ALFG
0.718 0.727 0.689 0.723 0.728 0.765 0.681 0.711 0.661 0.622 0.668 0.743             H07
 BETG  BETG  BETG  BETG  BETG  BETG  BETG  BETG  BETG  BETG  BETG  BETG
0.566 0.618 0.734 0.717 0.613 0.453 0.571 0.561 0.671 0.627 0.621 0.589             H08
   RI    RI    RI    RI    RI    RI    RI    RI    RI    RI    RI    RI
 0.92  0.60  1.03  0.91  1.21  1.17  1.66  1.18  1.46  1.29  1.35  0.83             H09
  --------------------------------
   The monthly temp values may be
   blank if IFT on record A04 is 0
  --------------------------------
 TAMX  TAMX  TAMX  TAMX  TAMX  TAMX  TAMX  TAMX  TAMX  TAMX  TAMX  TAMX
 52.0  53.7  60.3  70.1  79.0  85.7  87.0  86.6  81.8  72.4  61.0  52.4             H10
 TAMN  TAMN  TAMN  TAMN  TAMN  TAMN  TAMN  TAMN  TAMN  TAMN  TAMN  TAMN
 37.3  38.4  42.5  50.2  60.0  67.5  70.7  69.8  64.3  52.4  41.5  37.1             H11
  -------------------------------------
   The monthly radiation  values may be
   blank if IFT on record A04 is <2
  -------------------------------------
   RA    RA    RA    RA    RA    RA    RA    RA    RA    RA    RA    RA
218.0 290.0 380.0 488.0 533.0 562.0 532.0 508.0 416.0 344.0 268.0 211.0             H12
  ----------------------------------------------------
  Pan coefficient can be blank unless radiation values
  contain evap pan data (IPAN on record A03 is 1)
  ----------------------------------------------------
 TP05   TP6  COEFF
 2.38  4.88    1.2                                                                  H13
************************************************
************************************************
**                                            **
**          R A I N F A L L   D A T A         **
**                                            **
************************************************
```

```
*************************************************************
   72          0    0    0    0    0    0    0    0    0    0          1
   72          0    0    0    0    0    0    0    0    0    0          2
   72          0    0    0    0    0    0    0    0    0    0          3
( etc.)
```

Appendix D. Parameters of Weather Input:

Part 1, Tables of Monthly Statistics

(from Arlin Nicks, USDA-ARS, Durant, OK, and
Clarence Richardson, USDA-ARS, Temple, TX;
personal communication)

ALABAMA - BIRMINGHAM alat(deg)= 33.57 yrs= 62. elev (m)= 185.9 tp05(mm)= 71.1 tp6(mm)= 152.4

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.491	0.505	0.475	0.444	0.530	0.481	0.548	0.426	0.480	0.395	0.457	0.495
prw1(m)	0.264	0.299	0.285	0.245	0.183	0.220	0.307	0.265	0.175	0.144	0.213	0.267
alfg(m)	0.643	0.640	0.648	0.712	0.675	0.626	0.802	0.660	0.676	0.630	0.715	0.647
betg(m)	18.03	19.43	21.46	18.39	16.81	17.75	12.67	15.98	18.90	18.19	15.06	19.53
ri(m)	26.2	17.8	35.3	21.1	35.6	18.5	27.9	32.8	36.1	19.6	18.3	20.3
tamx(m)	13.1	14.6	18.5	23.3	27.5	31.5	32.3	32.2	30.2	24.9	17.8	13.4
tamn(m)	1.6	2.8	5.7	9.9	14.2	18.9	20.6	20.1	17.3	10.3	4.4	1.7
ra(m)	235.	294.	349.	476.	549.	548.	556.	520.	442.	370.	278.	204.

ALABAMA - MOBILE alat(deg)= 30.68 yrs= 16. elev (m)= 64.3 tp05(mm)= 88.6 tp6(mm)= 215.9

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.419	0.483	0.514	0.340	0.419	0.547	0.593	0.515	0.538	0.444	0.375	0.493
prw1(m)	0.294	0.286	0.257	0.197	0.202	0.280	0.446	0.351	0.232	0.135	0.193	0.271
alfg(m)	0.577	0.629	0.556	0.512	0.644	0.623	0.713	0.686	0.548	0.645	0.613	0.624
betg(m)	19.46	20.73	24.61	36.42	22.91	20.29	17.70	19.66	28.17	16.74	15.95	22.71
ri(m)	21.6	25.7	61.5	63.0	71.1	36.1	37.3	35.6	40.4	36.8	53.3	23.6
tamx(m)	16.8	18.2	20.6	24.6	28.2	31.4	31.9	32.1	30.3	26.3	20.6	17.2
tamn(m)	6.2	7.3	9.9	13.9	17.8	21.4	22.2	22.2	20.4	14.9	9.1	6.6
ra(m)	250.	309.	364.	491.	564.	563.	571.	535.	457.	385.	293.	219.

ALABAMA - MONTGOMERY alat(deg)= 32.30 yrs= 85. elev (m)= 60.4 tp05(mm)= 74.9 tp6(mm)= 171.4

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.447	0.456	0.435	0.380	0.475	0.457	0.436	0.408	0.514	0.444	0.348	0.471
prw1(m)	0.269	0.289	0.262	0.219	0.185	0.220	0.317	0.264	0.166	0.117	0.175	0.279
alfg(m)	0.713	0.691	0.699	0.634	0.634	0.706	0.620	0.762	0.546	0.601	0.684	0.691
betg(m)	13.33	17.27	19.96	21.64	17.30	14.96	16.46	10.36	29.95	19.48	15.72	17.45
ri(m)	18.8	33.5	26.2	27.9	31.8	31.0	39.9	41.9	39.6	25.4	24.4	11.7
tamx(m)	15.4	16.9	20.3	24.8	29.0	32.5	32.9	32.8	31.1	26.1	19.6	15.6
tamn(m)	3.7	4.8	7.5	11.5	15.9	20.4	21.7	21.5	19.0	12.2	6.2	3.7
ra(m)	245.	304.	359.	486.	559.	558.	566.	530.	452.	380.	288.	214.

ARIZONA - FLAGSTAFF alat(deg)= 35.13 yrs= 16. elev (m)=2131.5 tp05(mm)= 50.8 tp6(mm)= 88.9

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.558	0.470	0.483	0.464	0.362	0.490	0.545	0.515	0.438	0.470	0.495	0.536
prw1(m)	0.114	0.138	0.151	0.127	0.073	0.051	0.254	0.279	0.132	0.082	0.114	0.115
alfg(m)	0.895	0.889	0.854	0.945	0.983	0.592	0.826	0.782	0.659	0.811	0.689	0.729
betg(m)	8.31	7.42	8.08	6.53	4.75	10.74	7.19	8.23	11.48	8.81	11.07	12.95
ri(m)	5.1	10.4	5.6	6.6	5.3	5.6	27.9	17.8	10.2	5.3	6.3	3.6
tamx(m)	4.7	5.9	9.7	14.8	19.9	25.2	27.4	26.1	23.7	17.3	10.8	6.6
tamn(m)	-9.9	-8.6	-5.8	-2.2	1.1	5.3	9.8	9.3	5.7	-0.7	-6.3	-8.4
ra(m)	291.	399.	516.	628.	714.	729.	648.	603.	556.	439.	334.	271.

ARIZONA - PHOENIX alat(deg)= 33.43 yrs= 28. elev (m)= 340.5 tp05(mm)= 54.6 tp6(mm)= 101.6

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.407	0.478	0.364	0.303	0.294	0.313	0.366	0.318	0.429	0.354	0.327	0.400
prw1(m)	0.085	0.077	0.070	0.042	0.018	0.022	0.099	0.147	0.057	0.054	0.060	0.078
alfg(m)	0.825	0.822	1.031	0.883	0.899	0.629	0.752	0.650	0.532	0.680	0.917	0.746
betg(m)	5.71	4.62	5.97	5.05	3.56	6.88	5.92	8.51	11.73	7.87	5.59	8.20
ri(m)	6.1	5.8	8.6	4.6	15.0	2.5	24.1	31.2	8.4	5.6	6.1	9.1
tamx(m)	17.8	20.1	23.9	28.8	33.8	38.7	40.3	38.7	36.8	30.4	23.2	18.9
tamn(m)	1.8	3.8	6.1	10.2	13.9	18.6	23.9	23.0	19.6	12.6	5.8	2.8
ra(m)	301.	409.	526.	638.	724.	739.	658.	613.	566.	449.	344.	281.

ARIZONA - YUMA alat(deg)= 32.67 yrs= 15. elev (m)= 59.1 tp05(mm)= 31.8 tp6(mm)= 62.2

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.273	0.077	0.250	0.176	-	-	0.238	0.211	0.313	0.318	0.222	0.349
prw1(m)	0.056	0.048	0.041	0.024	0.008	-	0.030	0.052	0.017	0.025	0.038	0.047
alfg(m)	0.841	0.763	1.077	0.517	0.802	-	0.637	0.670	0.394	0.686	0.624	0.882
betg(m)	4.57	5.21	2.41	8.43	3.23	-	6.30	6.43	22.23	8.31	7.01	5.00
ri(m)	8.9	4.6	5.6	2.5	2.3	0.5	3.0	25.4	3.6	8.1	3.6	5.3
tamx(m)	20.7	23.3	27.1	31.3	35.4	39.7	42.3	41.4	39.7	33.3	25.9	21.6
tamn(m)	5.3	6.8	10.1	13.6	17.4	21.7	26.8	25.8	22.7	15.9	9.4	6.2
ra(m)	269.	374.	500.	600.	648.	712.	656.	616.	556.	422.	326.	262.

ARKANSAS - FORT SMITH alat(deg)= 35.33 yrs= 23. elev (m)= 136.2 tp05(mm)= 78.7 tp6(mm)= 163.8

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.426	0.444	0.394	0.479	0.445	0.407	0.421	0.341	0.432	0.366	0.423	0.444
prw1(m)	0.157	0.216	0.238	0.280	0.245	0.210	0.195	0.171	0.171	0.134	0.147	0.165
alfg(m)	0.655	0.701	0.719	0.709	0.658	0.632	0.590	0.650	0.752	0.625	0.638	0.719
betg(m)	11.35	12.73	14.58	15.85	20.22	17.12	19.35	18.54	15.34	24.28	20.40	13.56
ri(m)	8.1	21.1	25.1	23.4	36.6	30.5	23.9	25.4	35.6	22.9	29.0	15.7
tamx(m)	10.1	12.6	17.0	23.1	27.2	32.1	34.8	34.6	30.7	24.9	16.6	11.4
tamn(m)	-1.4	0.4	4.2	9.9	14.9	19.7	21.8	21.3	16.9	10.4	3.4	0.0
ra(m)	183.	255.	348.	441.	518.	554.	551.	513.	434.	338.	239.	182

ARKANSAS - LITTLE ROCK alat(deg)= 34.73 yrs= 27. elev (m)= 78.3 tp05(mm)= 74.9 tp6(mm)= 153.7

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.489	0.437	0.500	0.498	0.500	0.480	0.401	0.383	0.396	0.367	0.392	0.462
prw1(m)	0.217	0.267	0.242	0.270	0.190	0.179	0.233	0.177	0.174	0.154	0.186	0.225
alfg(m)	0.619	0.681	0.790	0.686	0.554	0.651	0.703	0.581	0.624	0.659	0.633	0.665
betg(m)	17.75	17.98	14.33	18.54	27.69	16.87	15.24	18.03	23.09	15.95	20.90	17.63
ri(m)	13.7	16.8	21.6	29.2	25.9	32.3	38.4	36.8	31.8	26.9	21.3	9.1
tamx(m)	10.3	12.6	17.1	23.1	27.5	32.1	33.7	33.6	30.2	24.4	16.3	11.2
tamn(m)	-0.8	1.2	4.9	10.7	15.3	20.0	21.7	21.2	16.8	10.1	3.1	-0.2
ra(m)	188.	260.	353.	446.	523.	559.	556.	518.	439.	343.	244.	187.

CALIFORNIA - BAKERSFIELD alat(deg)= 35.42 yrs= 32. elev (m)= 144.8 tp05(mm)= 25.4 tp6(mm)= 53.3

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.425	0.482	0.346	0.474	0.297	0.444	0.300	0.250	0.214	0.391	0.364	0.303
prw1(m)	0.132	0.132	0.130	0.095	0.039	0.008	0.010	0.006	0.019	0.022	0.082	0.117
alfg(m)	0.966	0.827	0.845	0.822	0.841	0.805	0.800	0.796	0.893	0.967	0.999	0.913
betg(m)	4.44	5.46	4.11	5.44	2.92	2.84	2.29	1.60	3.43	6.48	5.89	3.94
ri(m)	5.1	5.1	5.6	3.0	6.6	1.0	0.5	5.6	7.4	15.2	4.6	5.6
tamx(m)	14.1	17.2	20.7	24.3	29.2	33.4	37.9	36.5	33.2	27.2	20.3	15.0
tamn(m)	3.0	5.0	6.9	10.1	13.4	16.7	20.1	18.7	16.2	11.5	6.2	3.6
ra(m)	238.	326.	474.	549.	642.	700.	678.	645.	640.	438.	264.	207.

CALIFORNIA - BLUE CANYON alat(deg)= 39.28 yrs= 30. elev (m)=1609.3 tp05(mm)= 30.5 tp6(mm)= 170.2

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.731	0.678	0.663	0.631	0.556	0.488	0.067	0.296	0.370	0.437	0.628	0.710
prw1(m)	0.208	0.213	0.231	0.184	0.155	0.073	0.025	0.032	0.054	0.090	0.200	0.174
alfg(m)	0.716	0.808	0.880	0.721	0.798	0.742	0.996	0.439	0.600	0.567	0.710	0.791
betg(m)	40.56	26.75	20.27	19.74	11.76	8.89	1.78	15.62	11.58	43.03	30.18	36.37
ri(m)	9.4	6.1	5.6	5.8	6.1	5.1	6.9	9.4	6.9	9.1	6.3	7.1
tamx(m)	6.4	6.3	7.9	11.7	15.7	19.6	25.0	24.8	22.2	16.8	12.1	8.6
tamn(m)	-0.8	-0.7	0.4	3.3	6.7	10.6	15.0	13.8	12.2	7.4	3.1	0.6
ra(m)	178.	261.	394.	532.	629.	698.	686.	616.	497.	351.	226.	152.

CALIFORNIA - EUREKA alat(deg)= 40.80 yrs= 59. elev (m)= 13.1 tp05(mm)= 26.7 tp6(mm)= 137.2

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.754	0.693	0.724	0.615	0.518	0.398	0.122	0.306	0.397	0.529	0.691	0.718
prw1(m)	0.331	0.265	0.261	0.209	0.167	0.128	0.064	0.058	0.095	0.177	0.272	0.266
alfg(m)	0.837	0.758	0.968	0.777	0.743	0.777	1.053	0.499	0.651	0.851	0.719	0.877
betg(m)	14.12	12.85	8.41	9.12	7.49	3.81	1.19	7.34	6.99	9.63	15.80	12.95
ri(m)	13.7	20.6	6.3	4.6	5.6	6.6	1.8	4.3	11.4	9.4	13.2	14.0
tamx(m)	12.0	12.3	12.5	13.2	14.4	15.6	15.8	16.1	16.4	15.7	14.2	12.8
tamn(m)	5.1	5.6	6.0	7.3	8.9	10.5	11.1	11.4	10.6	9.2	7.2	5.9
ra(m)	149.	249.	346.	498.	599.	675.	700.	614.	452.	300.	174.	99.

CALIFORNIA - FRESNO alat(deg)= 36.77 yrs= 20. elev (m)= 100.0 tp05(mm)= 24.9 tp6(mm)= 75.7

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.509	0.519	0.393	0.477	0.340	0.158	0.160	54.002	0.368	0.250	0.479	0.458
prw1(m)	0.172	0.156	0.140	0.105	0.056	0.024	0.010	0.634	0.019	0.046	0.103	0.111
alfg(m)	0.724	0.759	0.852	0.752	1.044	1.087	1.100	0.000	0.847	0.578	0.785	0.708
betg(m)	9.75	8.46	7.95	9.07	3.25	1.78	2.29	0.00	5.66	5.84	8.08	9.47
ri(m)	7.9	5.8	8.1	4.6	2.3	2.5	0.5	1.5	4.8	16.8	5.1	10.2
tamx(m)	13.0	16.3	19.9	24.5	29.2	33.4	37.8	36.4	33.4	27.1	19.7	13.6
tamn(m)	2.6	4.2	5.6	8.0	11.0	14.0	17.0	15.6	13.5	9.2	4.4	3.1
ra(m)	184.	289.	427.	552.	647.	702.	682.	621.	510.	376.	250.	161.

CALIFORNIA - SAN FRANCISCO alat(deg)= 37.62 yrs= 33. elev (m)= 15.8 tp05(mm)= 31.8 tp6(mm)= 101.6

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.662	0.602	0.566	0.515	0.429	0.250	0.091	0.238	0.280	0.385	0.587	0.680
prw1(m)	0.225	0.193	0.203	0.121	0.063	0.042	0.016	0.030	0.028	0.090	0.168	0.166
alfg(m)	0.725	0.762	0.762	0.803	0.744	0.512	0.900	0.769	0.486	0.535	0.702	0.761
betg(m)	13.97	9.78	8.59	8.36	5.05	6.45	3.81	2.11	10.67	12.14	10.74	12.37
ri(m)	14.0	13.0	9.1	10.2	1.5	1.5	4.1	3.8	3.8	12.7	14.0	9.4
tamx(m)	13.2	14.8	15.9	16.6	17.4	18.3	17.9	18.3	20.5	20.2	17.6	14.2
tamn(m)	7.5	8.5	9.2	9.7	10.7	11.7	11.8	12.2	12.8	12.4	10.6	8.6
ra(m)	150.	250.	350.	532.	592.	660.	672.	602.	451.	320.	224.	124.

COLORADO - COLORADO SPRINGS alat(deg)= 38.82 yrs= 19. elev (m)=1873.0 tp05(mm)= 47.0 tp6(mm)= 85.1

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.333	0.400	0.467	0.456	0.530	0.487	0.521	0.559	0.423	0.424	0.366	0.329
prw1(m)	0.098	0.123	0.173	0.159	0.232	0.235	0.400	0.253	0.140	0.111	0.098	0.087
alfg(m)	0.905	1.085	0.850	0.656	0.601	0.607	0.708	0.755	0.716	0.774	0.885	1.124
betg(m)	1.96	1.57	2.90	6.71	9.17	9.65	7.62	7.06	7.67	5.69	3.58	1.60
ri(m)	2.3	0.8	3.8	7.4	18.8	37.6	19.3	50.8	20.1	77.7	4.3	1.0
tamx(m)	5.5	7.1	9.8	14.9	20.2	25.8	29.0	28.2	24.4	18.2	10.7	7.1
tamn(m)	-9.3	-7.7	-5.1	0.2	5.3	10.5	13.7	13.1	8.4	2.2	-4.7	-7.4
ra(m)	206.	273.	406.	465.	465.	530.	525.	444.	417.	315.	527.	187.

COLORADO - DENVER alat(deg)= 39.75 yrs= 33. elev (m)=1610.3 tp05(mm)= 45.7 tp6(mm)= 82.5

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.423	0.384	0.503	0.483	0.540	0.443	0.435	0.373	0.419	0.408	0.427	0.394
prw1(m)	0.130	0.177	0.201	0.202	0.208	0.246	0.237	0.228	0.149	0.113	0.122	0.126
alfg(m)	0.781	0.853	0.790	0.655	0.611	0.637	0.634	0.600	0.693	0.690	0.948	1.080
betg(m)	3.00	3.86	4.55	7.42	11.51	7.49	8.46	7.06	7.42	7.92	79.98	2.18
ri(m)	1.8	3.6	3.3	4.8	8.4	10.4	17.5	31.5	11.7	4.1	3.6	3.0
tamx(m)	5.6	7.0	9.9	15.8	21.4	27.8	31.3	30.4	26.1	19.2	10.9	7.3
tamn(m)	-9.6	-7.6	-5.1	0.2	5.4	10.6	14.1	13.4	8.3	2.3	-4.7	-7.8
ra(m)	203.	270.	403.	462.	462.	527.	522.	441.	414.	312.	224.	184.

COLORADO - GRAND JUNCTION alat(deg)= 39.12 yrs= 21. elev (m)=1479.8 tp05(mm)= 32.3 tp6(mm)= 57.1

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.407	0.410	0.388	0.404	0.476	0.427	0.318	0.384	0.391	0.475	0.385	0.344
prw1(m)	0.173	0.183	0.179	0.168	0.107	0.086	0.114	0.184	0.136	0.107	0.127	0.169
alfg(m)	0.947	0.994	1.024	0.849	0.821	0.835	0.764	0.794	0.840	0.983	0.918	0.973
betg(m)	2.44	2.26	2.31	3.25	3.81	3.94	3.07	4.80	4.47	4.37	3.33	2.51
ri(m)	2.0	2.8	3.0	4.1	3.3	5.1	32.5	7.9	8.4	4.1	3.0	3.0
tamx(m)	1.6	5.4	11.6	18.3	24.1	29.9	33.6	31.7	27.3	19.7	9.7	3.4
tamn(m)	-8.3	-4.8	-1.0	4.2	9.4	13.7	17.7	16.7	12.4	5.9	-2.2	-6.7
ra(m)	227.	324.	434.	546.	615.	708.	676.	595.	514.	373.	260.	212.

COLORADO - PUEBLO alat(deg)= 38.28 yrs= 27. elev (m)=1427.7 tp05(mm)= 48.3 tp6(mm)= 88.4

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.362	0.411	0.455	0.404	0.455	0.417	0.370	0.417	0.301	0.372	0.292	0.435
prw1(m)	0.104	0.113	0.136	0.116	0.172	0.180	0.246	0.230	0.143	0.092	0.093	0.071
alfg(m)	0.935	1.138	0.966	0.634	0.650	0.693	0.720	0.615	0.661	0.719	0.939	0.928
betg(m)	1.68	1.45	2.54	8.31	8.18	5.77	7.47	8.79	6.25	8.18	3.58	2.31
ri(m)	0.8	1.0	4.8	11.7	19.3	34.3	21.1	30.2	5.1	2.3	2.0	3.0
tamx(m)	7.4	9.2	12.7	18.8	24.1	30.5	33.4	32.1	28.1	21.6	13.2	9.3
tamn(m)	-9.6	-7.1	-3.7	1.9	7.7	12.9	16.0	15.3	10.3	3.7	-4.3	-8.0
ra(m)	208.	275.	408.	467.	467.	532.	527.	446.	419.	317.	529.	189.

CONNECTICUT - HARTFORD (WINDSOR LOCKS) alat(deg)= 41.93 yrs= 53. elev (m)= 51.5 tp05(mm)= 57.1 tp6(mm)= 125.7

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.406	0.454	0.445	0.475	0.412	0.469	0.356	0.387	0.444	0.421	0.513	0.493
prw1(m)	0.311	0.311	0.301	0.310	0.309	0.295	0.275	0.274	0.236	0.182	0.297	0.297
alfg(m)	0.780	0.650	0.755	0.689	0.725	0.667	0.702	0.594	0.556	0.641	0.687	0.694
betg(m)	90.30	12.32	12.37	12.80	9.37	11.53	11.86	18.24	19.05	17.63	13.46	12.85
ri(m)	7.6	7.1	6.6	14.7	16.0	14.7	36.1	33.0	22.9	36.8	5.6	10.2
tamx(m)	2.3	3.3	8.6	15.5	22.4	27.2	29.8	28.3	24.2	18.2	10.8	3.9
tamn(m)	-7.8	-7.7	-2.8	2.2	8.3	13.8	16.7	15.5	11.2	5.0	-0.4	-6.6
ra(m)	154.	219.	300.	354.	456.	512.	525.	450.	350.	238.	166.	124.

DELAWARE - WILMINGTON alat(deg)= 39.67 yrs= 10. elev (m)= 23.8 tp05(mm)= 69.8 tp6(mm)= 139.7

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.450	0.410	0.451	0.482	0.462	0.393	0.401	0.420	0.437	0.428	0.460	0.476
prw1(m)	0.263	0.282	0.312	0.318	0.291	0.244	0.251	0.244	0.172	0.162	0.245	0.226
alfg(m)	0.783	0.727	0.732	0.771	0.692	0.674	0.578	0.684	0.592	0.667	0.699	0.746
betg(m)	8.51	11.05	11.89	9.58	9.25	13.64	19.66	16.64	21.64	13.97	13.06	12.55
ri(m)	7.6	9.9	12.2	14.7	18.8	28.4	26.9	28.2	28.4	15.5	7.9	17.5
tamx(m)	5.4	6.0	11.7	17.3	23.7	28.4	30.4	29.2	26.0	19.6	12.9	6.6
tamn(m)	-4.1	-4.1	0.0	4.7	10.6	15.8	18.3	17.2	13.9	7.3	2.1	-3.2
ra(m)	156.	226.	317.	402.	481.	526.	508.	454.	384.	277.	191.	139.

FLORIDA - JACKSONVILLE alat(deg)= 30.50 yrs= 30. elev (m)= 7.9 tp05(mm)= 80.0 tp6(mm)= 182.9

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.401	0.398	0.408	0.320	0.477	0.564	0.555	0.584	0.598	0.505	0.330	0.370
prw1(m)	0.212	0.253	0.190	0.172	0.181	0.294	0.391	0.342	0.320	0.200	0.157	0.191
alfg(m)	0.677	0.731	0.626	0.670	0.586	0.651	0.676	0.613	0.622	0.545	0.665	0.677
betg(m)	12.34	17.02	17.60	17.17	19.56	20.32	17.93	23.52	20.19	22.07	10.64	12.70
ri(m)	23.9	28.2	33.5	36.8	126.7	24.4	38.9	71.4	42.7	29.2	15.7	15.5
tamx(m)	19.3	20.3	22.9	26.4	30.2	32.5	33.3	33.0	30.9	26.8	22.3	19.3
tamn(m)	7.2	8.1	10.6	14.3	18.4	21.7	22.9	22.9	21.7	16.6	10.7	7.5
ra(m)	262.	338.	422.	512.	574.	516.	483.	478.	413.	342.	295.	228.

FLORIDA - MIAMI alat(deg)= 25.72 yrs= 29. elev (m)= 2.1 tp05(mm)=101.6 tp6(mm)= 231.1

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.328	0.364	0.286	0.345	0.597	0.631	0.624	0.599	0.697	0.650	0.359	0.360
prw1(m)	0.182	0.173	0.174	0.160	0.196	0.413	0.382	0.422	0.401	0.319	0.196	0.142
alfg(m)	0.622	0.634	0.662	0.611	0.601	0.679	0.707	0.635	0.631	0.549	0.549	0.562
betg(m)	14.05	14.66	13.03	18.67	27.71	23.22	14.20	16.69	20.29	26.09	17.27	13.54
ri(m)	22.4	24.9	27.9	31.2	35.6	71.1	44.5	59.7	44.5	43.2	26.9	19.3
tamx(m)	24.3	25.0	26.6	28.1	29.7	31.1	31.6	32.1	31.1	29.3	26.8	25.1
tamn(m)	14.4	14.9	16.2	18.8	20.9	23.1	23.7	23.8	23.7	21.6	18.1	15.1
ra(m)	349.	415.	489.	540.	553.	532.	532.	505.	440.	384.	353.	316.

FLORIDA - TALLAHASSEE alat(deg)= 30.38 yrs= 11. elev (m)= 16.8 tp05(mm)= 82.5 tp6(mm)= 215.9

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.387	0.433	0.404	0.379	0.483	0.573	0.633	0.577	0.500	0.437	0.344	0.387
prw1(m)	0.241	0.286	0.225	0.187	0.206	0.304	0.496	0.329	0.254	0.110	0.163	0.219
alfg(m)	0.744	0.696	0.628	0.591	0.722	0.652	0.670	0.745	0.555	0.656	0.625	0.696
betg(m)	14.81	21.08	24.71	22.89	15.95	21.23	18.47	16.89	32.72	22.94	19.51	19.81
ri(m)	41.7	24.1	43.2	34.8	59.4	52.6	36.8	44.7	33.8	35.8	30.0	21.8
tamx(m)	18.4	19.4	22.3	26.1	30.2	32.5	32.5	32.4	30.7	27.0	21.7	18.6
tamn(m)	5.9	6.8	9.4	13.3	17.4	21.1	22.2	22.1	20.5	14.8	8.5	6.0
ra(m)	274.	311.	423.	499.	547.	521.	508.	542.	451.	378.	292.	230.

FLORIDA - TAMPA alat(deg)= 27.97 yrs= 25. elev (m)= 5.8 tp05(mm)= 88.9 tp6(mm)= 205.7

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.309	0.409	0.397	0.370	0.359	0.568	0.602	0.583	0.553	0.438	0.327	0.267
prw1(m)	0.180	0.201	0.169	0.118	0.169	0.270	0.436	0.474	0.350	0.178	0.132	0.181
alfg(m)	0.669	0.719	0.631	0.687	0.578	0.655	0.624	0.701	0.632	0.672	0.641	0.687
betg(m)	13.36	16.10	24.16	15.77	19.25	18.11	20.60	16.97	18.26	12.45	16.41	12.62
ri(m)	15.0	14.0	15.2	19.0	37.8	57.7	30.7	34.5	43.9	29.2	31.8	10.9
tamx(m)	21.8	22.7	24.4	27.4	30.6	31.9	32.1	32.4	31.5	28.8	24.9	22.5
tamn(m)	10.6	11.4	13.3	16.3	19.2	22.1	23.0	23.2	22.4	18.7	13.8	11.2
ra(m)	327.	391.	474.	539.	596.	574.	534.	494.	452.	400.	356.	300.

GEORGIA - ATLANTA alat(deg)= 33.65 yrs= 34. elev (m)= 307.8 tp05(mm)= 68.6 tp6(mm)= 146.1

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.502	0.490	0.433	0.426	0.462	0.473	0.548	0.437	0.490	0.561	0.385	0.468
prw1(m)	0.261	0.291	0.286	0.247	0.188	0.258	0.318	0.208	0.163	0.119	0.207	0.258
alfg(m)	0.718	0.727	0.689	0.723	0.728	0.765	0.681	0.711	0.661	0.622	0.668	0.743
betg(m)	14.38	15.70	18.64	18.21	15.57	11.51	14.50	14.25	17.04	15.93	15.77	14.96
ri(m)	23.4	15.2	26.2	23.1	30.7	29.7	42.2	30.0	37.1	32.8	34.3	21.1
tamx(m)	11.1	12.1	15.7	21.2	26.1	29.8	30.6	30.3	27.7	22.4	16.1	11.3
tamn(m)	2.9	3.6	5.8	10.1	15.1	19.7	21.5	21.0	17.9	11.3	5.3	2.8
ra(m)	218.	290.	380.	488.	533.	562.	532.	508.	416.	344.	268.	211.

GEORGIA - AUGUSTA alat(deg)= 33.37 yrs= 18. elev (m)= 41.5 tp05(mm)= 71.1 tp6(mm)= 147.3

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.477	0.434	0.473	0.436	0.503	0.492	0.532	0.437	0.458	0.482	0.414	0.456
prw1(m)	0.232	0.290	0.253	0.220	0.183	0.227	0.271	0.233	0.180	0.113	0.165	0.220
alfg(m)	0.733	0.797	0.689	0.637	0.754	0.813	0.614	0.641	0.694	0.643	0.618	0.738
betg(m)	13.41	13.64	16.61	16.69	14.12	12.98	17.68	17.65	16.05	14.17	11.76	12.42
ri(m)	18.0	16.0	17.5	21.1	35.6	34.8	40.9	38.4	50.0	37.1	13.5	15.2
tamx(m)	15.0	16.4	19.6	24.7	29.1	32.6	32.9	32.8	30.3	25.6	19.8	15.2
tamn(m)	2.1	2.8	5.8	9.9	14.9	19.6	21.1	20.7	17.8	11.3	4.7	1.7
ra(m)	224.	285.	375.	512.	560.	567.	546.	512.	425.	358.	273.	191.

GEORGIA - MACON alat(deg)= 32.70 yrs= 20. elev (m)= 107.9 tp05(mm)= 71.1 tp6(mm)= 151.4

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.468	0.519	0.478	0.398	0.524	0.472	0.559	0.502	0.503	0.492	0.370	0.442
prw1(m)	0.250	0.283	0.263	0.214	0.182	0.257	0.340	0.239	0.184	0.118	0.176	0.248
alfg(m)	0.701	0.799	0.666	0.632	0.597	0.637	0.692	0.751	0.623	0.594	0.734	0.756
betg(m)	13.39	14.20	18.03	17.60	18.54	16.00	12.98	11.99	16.03	16.59	11.10	14.73
ri(m)	18.3	21.3	20.3	30.0	24.6	44.7	25.4	37.1	37.3	14.5	14.7	11.4
tamx(m)	15.7	17.1	20.5	25.7	30.3	33.7	33.8	33.4	30.8	25.9	20.0	15.6
tamn(m)	3.4	4.1	7.1	11.6	16.2	20.4	21.7	21.3	18.5	12.1	5.9	3.3
ra(m)	237.	298.	388.	525.	573.	580.	559.	525.	438.	371.	286.	204.

GEORGIA - SAVANAH alat(deg)= 32.13 yrs= 18. elev (m)= 0.0 tp05(mm)= 81.3 tp6(mm)= 177.5

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.439	0.417	0.418	0.321	0.452	0.551	0.577	0.551	0.502	0.463	0.375	0.331
prw1(m)	0.229	0.283	0.251	0.194	0.203	0.264	0.394	0.292	0.244	0.131	0.158	0.215
alfg(m)	0.737	0.718	0.710	0.712	0.626	0.689	0.671	0.653	0.622	0.582	0.600	0.795
betg(m)	11.58	12.67	15.29	15.82	21.87	19.68	20.27	20.90	20.95	17.58	12.04	11.02
ri(m)	14.2	19.0	14.0	49.8	48.3	29.7	49.8	41.7	47.0	39.1	12.4	18.3
tamx(m)	16.9	18.0	20.9	25.2	29.3	32.3	32.9	32.7	29.9	25.6	20.6	17.0
tamn(m)	4.9	5.4	8.3	12.3	16.7	20.6	21.9	21.8	19.7	13.5	7.5	4.6
ra(m)	260.	322.	396.	520.	559.	572.	528.	509.	412.	346.	294.	233.

IDAHO - BOISE alat(deg)= 43.57 yrs= 31. elev (m)= 865.0 tp05(mm)= 19.0 tp6(mm)= 44.5

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.595	0.559	0.459	0.406	0.476	0.464	0.250	0.353	0.370	0.389	0.534	0.543
prw1(m)	0.317	0.235	0.223	0.211	0.196	0.150	0.053	0.063	0.083	0.152	0.213	0.271
alfg(m)	0.846	0.920	0.998	0.841	0.740	0.854	0.826	0.676	0.801	0.998	0.998	0.883
betg(m)	3.76	2.92	2.57	4.57	5.36	4.47	2.87	5.13	4.04	2.92	3.53	3.25
ri(m)	2.3	7.1	4.6	4.8	5.3	7.4	7.9	14.0	3.6	4.3	228.6	127.0
tamx(m)	2.3	5.8	10.8	17.4	22.2	26.9	33.0	31.5	26.0	18.5	9.1	4.1
tamn(m)	-5.5	-3.1	-0.1	3.0	6.9	10.6	15.0	13.1	8.1	3.3	-1.8	-3.9
ra(m)	138.	236.	342.	485.	585.	636.	670.	576.	460.	301.	182.	124.

IDAHO - POCATELLO alat(deg)= 42.92 yrs= 21. elev (m)=1357.6 tp05(mm)= 25.4 tp6(mm)= 49.5

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.511	0.524	0.479	0.380	0.508	0.509	0.286	0.360	0.353	0.370	0.450	0.548
prw1(m)	0.289	0.253	0.230	0.213	0.194	0.169	0.095	0.107	0.099	0.110	0.194	0.259
alfg(m)	0.949	0.998	0.998	0.998	0.794	0.824	0.850	0.706	0.836	0.884	0.987	0.992
betg(m)	2.46	2.03	2.08	3.68	4.24	4.70	2.82	5.05	3.71	4.19	2.82	2.29
ri(m)	2.0	3.0	2.8	3.0	3.6	7.9	12.7	3.8	4.6	13.7	3.0	1.8
tamx(m)	-0.2	2.5	7.8	15.4	20.7	25.4	32.0	30.8	25.0	17.7	7.4	2.4
tamn(m)	-10.6	-7.9	-3.6	0.7	4.9	8.7	12.8	11.5	6.4	1.3	-4.2	-7.5
ra(m)	162.	239.	354.	461.	551.	591.	601.	539.	431.	285.	175.	130.

ILLINOIS - CHICAGO alat(deg)= 41.98 yrs= 26. elev (m)= 185.0 tp05(mm)= 55.9 tp6(mm)= 106.7

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.430	0.430	0.485	0.559	0.441	0.458	0.437	0.357	0.455	0.456	0.460	0.483
prw1(m)	0.291	0.285	0.330	0.332	0.293	0.288	0.270	0.202	0.214	0.193	0.236	0.274
alfg(m)	0.681	0.782	0.705	0.733	0.783	0.692	0.602	0.689	0.718	0.640	0.735	0.666
betg(m)	6.38	5.23	7.54	10.77	9.07	13.92	18.67	16.56	12.70	13.64	8.25	7.11
ri(m)	13.0	6.3	14.5	45.2	15.7	57.1	56.1	36.1	28.7	13.0	5.8	6.3
tamx(m)	0.6	1.5	6.4	14.1	20.6	26.4	28.9	28.0	23.8	17.4	8.4	2.1
tamn(m)	-7.2	-6.3	-1.7	4.7	10.5	16.4	19.5	18.8	14.1	8.2	0.3	-5.3
ra(m)	96.	147.	227.	331.	424.	458.	473.	403.	313.	207.	120.	76.

INDIANA - EVANSVILLE alat(deg)= 38.05 yrs= 17. elev (m)= 116.7 tp05(mm)= 59.7 tp6(mm)= 120.7

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.467	0.457	0.485	0.483	0.493	0.459	0.455	0.393	0.418	0.446	0.440	0.490
prw1(m)	0.242	0.276	0.288	0.336	0.252	0.243	0.263	0.181	0.170	0.166	0.214	0.260
alfg(m)	0.673	0.725	0.622	0.669	0.697	0.676	0.743	0.654	0.629	0.659	0.707	0.648
betg(m)	12.17	11.99	16.13	12.93	15.44	12.90	13.13	15.06	15.34	12.80	12.88	13.41
ri(m)	7.1	10.7	13.2	19.0	27.7	31.2	39.4	47.0	25.7	13.7	29.7	6.3
tamx(m)	6.3	8.1	13.8	19.9	24.7	29.7	31.7	30.6	27.7	21.7	13.1	7.6
tamn(m)	-3.3	-1.9	2.4	7.9	12.5	17.7	19.6	18.6	15.1	8.7	2.4	-2.1
ra(m)	144.	233.	336.	416.	508.	563.	561.	510.	425.	313.	197.	152.

INDIANA - FORT WAYNE alat(deg)= 41.00 yrs= 11. elev (m)= 244.1 tp05(mm)= 53.3 tp6(mm)= 101.6

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.496	0.463	0.552	0.535	0.502	0.493	0.439	0.393	0.424	0.434	0.461	0.498
prw1(m)	0.326	0.309	0.359	0.389	0.305	0.253	0.297	0.217	0.238	0.202	0.277	0.313
alfg(m)	0.667	0.676	0.743	0.781	0.830	0.838	0.713	0.762	0.758	0.653	0.830	0.668
betg(m)	7.11	7.47	6.99	8.79	9.78	11.05	12.42	11.86	9.12	13.33	7.95	7.09
ri(m)	8.9	6.1	7.6	14.2	15.2	24.6	23.1	32.3	20.1	12.7	6.9	11.7
tamx(m)	0.8	1.9	7.4	14.3	20.9	26.3	29.1	27.8	23.9	17.2	8.4	1.9
tamn(m)	-7.2	-6.3	-2.2	3.2	9.1	14.7	17.0	16.0	12.3	6.3	0.2	-5.4
ra(m)	124.	193.	296.	376.	468.	523.	521.	470.	385.	273.	157.	112.

INDIANA - INDIANAPOLIS alat(deg)= 39.73 yrs=18. elev (m)=241.7 tp05(mm)=55.9 tp6(mm)=111.8

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.466	0.462	0.496	0.543	0.513	0.421	0.406	0.358	0.415	0.428	0.412	0.518
prw1(m)	0.291	0.277	0.344	0.332	0.304	0.266	0.273	0.218	0.192	0.175	0.259	0.291
alfg(m)	0.630	0.692	0.688	0.749	0.845	0.671	0.746	0.753	0.646	0.689	0.733	0.669
betg(m)	9.83	9.19	10.74	10.92	9.91	14.68	14.78	11.10	14.73	12.88	11.71	9.52
ri(m)	11.7	18.5	12.2	18.0	16.5	60.5	35.3	48.8	28.2	16.5	10.7	12.4
tamx(m)	2.8	4.3	9.9	16.6	22.7	28.2	31.1	29.7	26.0	19.6	10.3	3.8
tamn(m)	-6.4	-4.9	-0.9	4.3	9.9	15.6	17.8	16.9	13.1	6.9	0.3	-4.8
ra(m)	144.	213.	316.	396.	488.	543.	541.	490.	405.	293.	177.	132.

IOWA - DES MOINES alat(deg)= 41.53 yrs= 27. elev (m)= 285.9 tp05(mm)= 67.3 tp6(mm)= 129.5

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.391	0.397	0.490	0.466	0.455	0.489	0.367	0.393	0.444	0.389	0.403	0.384
prw1(m)	0.205	0.212	0.255	0.317	0.286	0.295	0.257	0.252	0.238	0.183	0.141	0.200
alfg(m)	0.762	0.821	0.698	0.713	0.681	0.664	0.697	0.693	0.691	0.661	0.536	0.831
betg(m)	3.99	4.37	7.67	9.40	14.53	14.40	13.46	14.02	12.67	10.39	11.91	3.78
ri(m)	3.8	5.6	10.2	25.4	23.9	41.4	42.9	41.7	21.8	15.5	8.1	5.8
tamx(m)	-1.9	0.1	6.1	15.2	21.9	27.4	30.7	29.3	24.9	18.7	8.1	0.8
tamn(m)	-11.5	-9.7	-4.1	3.3	9.9	15.9	18.4	17.4	12.1	5.9	-2.4	-8.3
ra(m)	176.	255.	328.	405.	482.	542.	538.	462.	369.	276.	189.	145.

IOWA - DUBUQUE alat(deg)= 42.40 yrs= 16. elev (m)= 321.9 tp05(mm)= 59.7 tp6(mm)= 115.6

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.411	0.396	0.483	0.472	0.478	0.475	0.405	0.395	0.422	0.475	0.391	0.444
prw1(m)	0.234	0.212	0.269	0.326	0.301	0.286	0.298	0.219	0.237	0.184	0.173	0.248
alfg(m)	0.722	0.804	0.814	0.802	0.733	0.752	0.673	0.752	0.644	0.746	0.595	0.744
betg(m)	5.77	5.11	8.74	12.29	14.17	14.33	17.12	17.27	20.19	13.41	16.08	6.76
ri(m)	2.5	6.6	9.7	26.2	29.7	23.6	32.0	35.8	17.5	9.1	13.5	5.6
tamx(m)	-2.6	-1.0	4.8	13.9	20.4	25.7	28.7	27.4	22.6	16.3	6.2	-0.6
tamn(m)	-11.6	-10.1	-4.9	2.4	8.6	14.1	16.4	15.3	10.4	4.4	-3.2	-8.9
ra(m)	174.	253.	326.	403.	480.	541.	436.	460.	367.	274.	187.	143.

KANSAS - DODGE CITY alat(deg)= 37.77 yrs= 15. elev (m)= 790.7 tp05(mm)= 74.9 tp6(mm)= 127.0

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.287	0.305	0.397	0.402	0.484	0.492	0.421	0.441	0.442	0.425	0.411	0.384
prw1(m)	0.109	0.138	0.150	0.157	0.233	0.213	0.247	0.209	0.144	0.096	0.074	0.103
alfg(m)	0.927	0.795	0.660	0.733	0.670	0.750	0.709	0.616	0.591	0.592	0.783	0.819
betg(m)	2.44	3.51	7.52	7.47	12.70	11.51	12.32	11.53	13.23	12.70	4.85	3.28
ri(m)	10.2	1.8	8.1	50.5	20.3	33.3	47.0	28.2	21.6	14.0	25.1	5.6
tamx(m)	5.6	8.4	13.1	19.3	24.0	30.1	33.8	32.9	28.1	21.4	12.9	6.9
tamn(m)	-7.4	-5.2	-1.3	4.9	10.4	16.1	19.4	18.8	14.0	7.2	-1.1	-5.4
ra(m)	255.	316.	418.	528.	568.	650.	642.	592.	493.	380.	285.	234.

KANSAS - TOPEKA alat(deg)= 39.07 yrs= 11. elev (m)= 267.3 tp05(mm)= 62.2 tp6(mm)= 147.3

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.336	0.301	0.480	0.471	0.460	0.471	0.442	0.381	0.419	0.419	0.388	0.342
prw1(m)	0.151	0.186	0.172	0.243	0.293	0.294	0.228	0.215	0.202	0.147	0.123	0.154
alfg(m)	0.773	0.708	0.748	0.626	0.780	0.720	0.698	0.652	0.755	0.695	0.592	0.894
betg(m)	4.29	5.94	8.71	13.79	11.20	18.80	17.40	17.73	14.00	14.22	11.91	5.89
ri(m)	5.3	6.1	15.5	18.8	42.7	39.4	40.6	29.0	32.0	46.5	17.5	14.2
tamx(m)	3.8	6.6	12.2	18.9	23.9	29.3	32.6	31.8	27.3	21.4	12.3	5.8
tamn(m)	-7.4	-5.1	-0.5	6.0	11.4	17.2	19.8	18.9	13.8	7.3	-0.6	-5.6
ra(m)	192.	264.	345.	433.	527.	551.	531.	526.	410.	292.	227.	156.

KANSAS - WICHITA alat(deg)= 37.65 yrs= 4. elev (m)= 402.6 tp05(mm)= 80.0 tp6(mm)= 149.9

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.500	0.316	0.462	0.419	0.393	0.577	[illegible]	[illegible]	0.412	0.231	0.400	0.250
prw1(m)	0.060	0.212	0.194	0.322	0.246	0.188	0.254	0.292	0.123	0.137	0.157	0.111
alfg(m)	0.621	0.734	0.524	0.551	0.690	0.786	0.640	0.989	0.724	0.998	0.609	0.858
betg(m)	6.50	6.50	16.92	12.78	16.26	15.95	16.10	7.72	16.23	10.57	11.71	5.89
ri(m)	7.9	4.6	17.0	16.0	23.9	25.9	27.7	25.4	34.3	21.6	15.0	9.4
tamx(m)	5.2	8.8	13.6	19.4	24.1	30.0	33.5	33.2	28.2	21.6	12.8	7.0
tamn(m)	-5.2	-3.1	1.2	7.4	12.5	18.1	20.8	20.0	15.8	9.7	1.7	-3.2
ra(m)	255.	316.	418.	528.	568.	650.	642.	592.	493.	380.	285.	234.

KENTUCKY - LEXINGTON alat(deg)= 38.03 yrs= 74. elev (m)= 298.4 tp05(mm)= 57.1 tp6(mm)= 107.9

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.496	0.489	0.502	0.520	0.500	0.526	0.430	0.394	0.441	0.400	0.459	0.478
prw1(m)	0.317	0.345	0.356	0.353	0.292	0.273	0.312	0.245	0.176	0.194	0.267	0.321
alfg(m)	0.630	0.751	0.652	0.647	0.680	0.778	0.734	0.631	0.666	0.725	0.708	0.678
betg(m)	11.79	10.06	14.66	12.14	13.59	12.88	14.22	15.32	14.91	9.22	11.73	11.35
ri(m)	10.2	16.5	12.7	14.2	38.1	25.4	36.8	31.2	29.0	14.0	15.0	10.2
tamx(m)	5.9	7.3	12.7	18.6	24.1	28.8	30.8	29.9	26.9	20.6	12.2	6.9
tamn(m)	-3.8	-2.9	1.0	6.3	11.6	16.7	18.7	17.8	14.7	8.1	1.9	-2.6
ra(m)	172.	263.	357.	480.	581.	628.	617.	563.	494.	357.	245.	174.

KENTUCKY - LOUISVILLE alat(deg)= 38.18 yrs= 85. elev (m)= 144.5 tp05(mm)= 57.1 tp6(mm)= 107.9

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.472	0.466	0.484	0.512	0.547	0.513	0.449	0.379	0.420	0.383	0.439	0.486
prw1(m)	0.301	0.323	0.355	0.331	0.256	0.222	0.297	0.201	0.182	0.188	0.257	0.291
alfg(m)	0.662	0.709	0.645	0.664	0.723	0.680	0.743	0.692	0.648	0.752	0.628	0.653
betg(m)	11.35	11.51	14.88	12.62	12.42	13.94	11.76	14.63	16.87	11.05	13.13	11.91
ri(m)	8.1	14.7	16.8	15.2	20.6	30.7	41.1	29.0	20.1	33.8	18.0	9.1
tamx(m)	6.4	7.9	13.3	19.4	24.8	29.6	31.7	30.8	27.7	21.4	12.9	7.5
tamn(m)	-3.2	-2.2	1.8	7.2	12.2	17.3	19.2	18.2	14.7	8.2	2.3	-2.1
ra(m)	168.	267.	353.	454.	585.	624.	613.	559.	490.	353.	241.	170.

LOUISIANA - BATON ROUGE alat(deg)= 30.53 yrs= 7. elev (m)= 19.5 tp05(mm)= 86.4 tp6(mm)= 205.7

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.381	0.466	0.398	0.376	0.506	0.531	0.560	0.452	0.416	0.376	0.305	0.464
prw1(m)	0.251	0.267	0.220	0.182	0.180	0.194	0.363	0.279	0.219	0.121	0.180	0.255
alfg(m)	0.654	0.664	0.645	0.582	0.652	0.811	0.700	0.767	0.721	0.617	0.712	0.725
betg(m)	17.37	21.13	18.77	33.30	20.42	11.48	18.08	14.43	14.73	21.23	18.85	17.93
ri(m)	27.4	30.0	27.9	44.7	47.0	24.1	46.0	42.2	71.9	29.2	38.4	27.9
tamx(m)	16.3	18.1	21.0	24.7	28.2	31.6	32.2	32.1	30.6	26.9	20.7	17.0
tamn(m)	6.3	8.1	10.4	14.0	18.0	21.3	22.3	22.1	19.9	14.9	9.4	7.0
ra(m)	214.	259.	335.	412.	449.	443.	417.	416.	383.	357.	278.	198.

LOUISIANA - NEW ORLEANS alat(deg)= 29.98 yrs= 87. elev (m)= 2.7 tp05(mm)= 88.9 tp6(mm)= 224.8

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.409	0.458	0.404	0.343	0.439	0.483	0.576	0.536	0.495	0.433	0.369	0.449
prw1(m)	0.253	0.279	0.227	0.197	0.191	0.258	0.368	0.329	0.237	0.130	0.168	0.274
alfg(m)	0.575	0.615	0.570	0.604	0.660	0.691	0.705	0.642	0.646	0.694	0.593	0.633
betg(m)	21.97	22.94	22.12	23.75	22.10	16.28	17.37	17.02	21.49	14.50	20.95	20.40
ri(m)	42.2	23.9	25.7	34.3	34.5	42.4	62.2	56.6	33.3	41.9	68.8	31.0
tamx(m)	17.5	19.2	21.7	25.4	28.8	31.9	32.4	32.5	30.7	26.7	21.2	18.2
tamn(m)	9.1	10.2	12.7	16.6	20.2	23.6	24.3	24.6	23.0	18.6	12.7	9.7
ra(m)	214.	259.	335.	412.	449.	443.	417.	416.	383.	357.	278.	198.

LOUISIANA - SHREVEPORT alat(deg)= 32.47 yrs= 6. elev (m)= 76.8 tp05(mm)= 82.5 tp6(mm)= 181.6

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.497	0.434	0.436	0.430	0.488	0.497	0.375	0.375	0.444	0.376	0.429	0.480
prw1(m)	0.221	0.237	0.248	0.245	0.186	0.154	0.187	0.163	0.163	0.131	0.205	0.222
alfg(m)	0.625	0.699	0.729	0.665	0.668	0.578	0.607	0.527	0.663	0.713	0.652	0.645
betg(m)	15.21	15.77	13.06	22.23	21.18	22.05	16.18	19.28	18.80	14.81	17.58	17.88
ri(m)	27.9	29.2	31.8	28.7	46.5	36.3	29.2	48.3	45.7	29.0	15.7	24.1
tamx(m)	13.4	15.7	19.8	24.9	28.6	32.8	34.1	34.8	31.7	26.5	18.8	14.7
tamn(m)	4.2	6.2	9.3	14.1	17.8	21.8	23.1	23.1	20.3	14.0	8.1	5.1
ra(m)	232.	292.	384.	446.	558.	557.	578.	528.	414.	354.	254.	205.

MAINE - CARIBOU alat(deg)= 46.87 yrs= 32. elev (m)= 190.2 tp05(mm)= 33.0 tp6(mm)= 85.1

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.516	0.518	0.539	0.508	0.531	0.472	0.500	0.508	0.473	0.498	0.573	0.527
prw1(m)	0.409	0.368	0.315	0.318	0.332	0.376	0.424	0.367	0.361	0.316	0.389	0.379
alfg(m)	0.779	0.826	0.756	0.808	0.858	0.782	0.719	0.682	0.609	0.676	0.788	0.720
betg(m)	4.88	5.51	5.77	6.71	6.30	8.08	9.78	11.13	12.37	10.16	7.72	7.11
ri(m)	7.1	3.8	4.1	6.3	12.2	13.2	22.6	30.5	12.2	6.3	6.3	4.8
tamx(m)	-6.8	-5.4	-0.1	7.2	15.9	20.7	23.9	23.0	17.8	11.1	2.7	-4.7
tamn(m)	-17.2	-16.3	-10.1	-2.4	3.9	9.2	12.2	11.0	6.4	1.1	-4.7	-13.6
ra(m)	133.	231.	364.	400.	476.	470.	508.	448.	336.	212.	111.	107.

MAINE - PORTLAND alat(deg)= 43.65 yrs= 31. elev (m)= 13.1 tp05(mm)= 45.7 tp6(mm)= 110.5

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.442	0.422	0.475	0.534	0.473	0.451	0.361	0.364	0.416	0.484	0.515	0.493
prw1(m)	0.295	0.341	0.281	0.310	0.321	0.310	0.261	0.299	0.234	0.229	0.308	0.299
alfg(m)	0.765	0.672	0.716	0.717	0.714	0.651	0.724	0.708	0.631	0.603	0.691	0.670
betg(m)	10.49	13.72	12.45	10.69	9.40	10.74	10.21	9.75	15.16	15.60	15.37	14.38
ri(m)	20.1	8.4	8.6	12.2	12.4	31.0	29.7	19.3	14.2	29.0	12.4	11.2
tamx(m)	-0.1	0.8	4.8	11.4	17.9	22.8	26.4	25.8	21.2	15.4	8.7	1.8
tamn(m)	-11.3	-11.1	-5.6	0.2	5.4	10.6	13.7	12.9	8.4	3.0	-1.9	-8.7
ra(m)	152.	235.	352.	409.	514.	539.	561.	488.	383.	278.	157.	137.

MARYLAND - BALTIMORE alat(deg)= 39.18 yrs= 17. elev (m)= 44.5 tp05(mm)= 69.8 tp6(mm)= 132.1

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.446	0.411	0.504	0.502	0.447	0.392	0.333	0.458	0.421	0.365	0.414	0.407
prw1(m)	0.263	0.264	0.293	0.319	0.277	0.260	0.243	0.247	0.180	0.164	0.251	0.244
alfg(m)	0.791	0.791	0.713	0.698	0.707	0.631	0.592	0.617	0.530	0.698	0.653	0.737
betg(m)	8.48	10.92	11.73	10.64	10.62	16.23	19.58	18.95	20.75	15.21	13.92	12.47
ri(m)	8.6	11.7	21.3	12.2	23.9	23.6	37.3	30.5	40.6	26.9	11.2	6.9
tamx(m)	6.8	7.5	12.0	18.8	24.4	28.6	30.7	29.4	25.9	20.2	13.6	7.6
tamn(m)	-3.7	-3.4	0.3	5.9	11.6	16.3	19.1	18.3	14.2	7.6	1.3	-3.4
ra(m)	168.	270.	334.	410.	504.	521.	506.	426.	371.	277.	198.	164.

MASSACHUSETTS - BOSTON alat(deg)= 42.37 yrs= 17. elev (m)= 4.6 tp05(mm)= 54.6 tp6(mm)= 119.4

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.460	0.476	0.500	0.511	0.461	0.443	0.402	0.401	0.375	0.454	0.523	0.456
prw1(m)	0.333	0.359	0.315	0.302	0.313	0.305	0.248	0.286	0.252	0.229	0.307	0.294
alfg(m)	0.689	0.618	0.662	0.720	0.670	0.680	0.663	0.582	0.562	0.607	0.601	0.679
betg(m)	11.58	14.33	14.17	12.04	11.91	10.85	11.38	16.18	18.01	15.14	16.59	16.26
ri(m)	7.6	9.7	9.9	10.4	7.6	9.4	22.1	24.6	20.1	24.6	6.3	12.7
tamx(m)	2.7	3.0	7.0	13.2	19.7	24.6	27.7	26.7	23.0	17.1	11.1	4.5
tamn(m)	-5.0	-4.9	-0.7	4.4	10.1	15.1	18.6	17.4	13.9	8.4	3.2	-3.1
ra(m)	129.	194.	290.	350.	445.	483.	486.	411.	334.	235.	136.	115.

MASSACHUSETTS - NANTUCKET alat(deg)= 41.25 yrs= 43. elev (m)= 13.1 tp05(mm)= 63.5 tp6(mm)= 127.0

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.498	0.443	0.445	0.483	0.412	0.355	0.316	0.397	0.461	0.448	0.527	0.500
prw1(m)	0.353	0.369	0.352	0.316	0.281	0.223	0.218	0.255	0.212	0.214	0.319	0.344
alfg(m)	0.763	0.697	0.723	0.699	0.652	0.660	0.636	0.644	0.571	0.665	0.660	0.718
betg(m)	10.54	13.67	12.40	11.81	12.88	10.21	15.32	16.66	18.47	15.01	13.84	12.52
ri(m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tamx(m)	4.0	3.4	5.8	10.3	15.5	19.9	23.5	23.6	20.7	16.0	11.3	5.8
tamn(m)	-2.9	-4.1	-1.3	3.3	7.4	12.7	16.5	16.5	13.6	8.8	4.2	-1.3
ra(m)	140.	218.	305.	385.	452.	508.	495.	436.	365.	258.	163.	140.

MICHIGAN - DETROIT alat(deg)= 42.23 yrs= 32. elev (m)= 188.7 tp05(mm)= 48.3 tp6(mm)= 92.7

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.496	0.465	0.500	0.527	0.463	0.455	0.357	0.352	0.450	0.468	0.493	0.510
prw1(m)	0.351	0.329	0.335	0.332	0.313	0.289	0.241	0.225	0.221	0.180	0.262	0.351
alfg(m)	0.695	0.775	0.772	0.741	0.684	0.776	0.713	0.704	0.778	0.672	0.743	0.651
betg(m)	5.36	5.16	5.87	8.61	8.76	9.86	12.06	13.41	8.51	11.18	7.34	6.63
ri(m)	6.6	8.4	8.9	10.9	21.8	18.8	43.4	38.9	13.2	9.7	5.6	6.9
tamx(m)	0.6	1.1	5.7	13.6	20.3	26.2	28.8	27.7	23.4	17.1	8.4	2.1
tamn(m)	-6.3	-6.4	-2.6	3.8	9.7	15.7	18.2	17.6	13.3	7.1	0.9	-4.4
ra(m)	116.	205.	304.	355.	478.	542.	535.	461.	368.	250.	131.	103.

MICHIGAN - GRAND RAPIDS alat(deg)= 42.88 yrs= 3. elev (m)= 239.0 tp05(mm)= 50.3 tp6(mm)= 95.3

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.661	0.510	0.554	0.534	0.469	0.408	0.391	0.382	0.438	0.476	0.578	0.624
prw1(m)	0.362	0.392	0.352	0.333	0.278	0.288	0.252	0.218	0.276	0.230	0.295	0.373
alfg(m)	0.802	0.788	0.762	0.772	0.706	0.699	0.756	0.757	0.646	0.673	0.727	0.805
betg(m)	3.89	3.99	5.79	9.47	9.63	13.06	11.13	11.73	12.90	11.46	8.18	4.39
ri(m)	6.6	10.9	7.9	13.2	19.0	23.4	25.4	34.5	14.7	17.3	10.4	9.1
tamx(m)	-0.4	0.1	5.3	13.7	20.5	26.3	29.2	28.1	23.5	17.1	7.9	1.3
tamn(m)	-8.5	-8.7	-4.5	1.6	7.2	13.1	15.6	14.6	10.0	4.2	-2.0	-6.8
ra(m)	120.	209.	308.	358.	482.	546.	539.	465.	372.	254.	135.	107.

MINNESOTA - DULUTH alat(deg)= 46.83 yrs= 30. elev (m)= 435.3 tp05(mm)= 51.3 tp6(mm)= 99.1

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.528	0.463	0.474	0.498	0.546	0.506	0.439	0.444	0.509	0.524	0.559	0.574
prw1(m)	0.291	0.272	0.269	0.291	0.342	0.324	0.307	0.324	0.298	0.212	0.239	0.296
alfg(m)	0.819	0.798	0.676	0.713	0.723	0.700	0.701	0.635	0.716	0.688	0.618	0.730
betg(m)	2.90	2.87	5.71	8.13	8.86	12.14	12.37	12.98	10.03	8.38	6.76	4.04
ri(m)	3.0	4.3	4.3	6.1	16.3	22.4	36.6	19.8	23.1	26.4	4.8	3.6
tamx(m)	-7.8	-5.9	-0.5	8.4	15.9	21.3	25.1	23.7	18.2	12.5	1.7	-5.4
tamn(m)	-18.1	-17.7	-11.4	-2.8	3.2	8.5	12.2	11.6	6.5	1.4	-6.9	-14.6
ra(m)	158.	250.	358.	416.	486.	525.	547.	476.	356.	227.	136.	114.

MINNESOTA - MINNEAPOLIS alat(deg)= 44.88 yrs= 33. elev (m)= 254.2 tp05(mm)= 59.7 tp6(mm)= 109.2

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.416	0.414	0.419	0.407	0.502	0.496	0.361	0.383	0.455	0.431	0.407	0.447
prw1(m)	0.221	0.188	0.275	0.283	0.321	0.331	0.304	0.266	0.252	0.182	0.198	0.247
alfg(m)	0.826	0.730	0.670	0.785	0.751	0.760	0.627	0.732	0.771	0.642	0.675	0.826
betg(m)	2.62	4.32	6.68	6.81	9.45	10.64	15.75	12.50	9.12	9.96	5.69	2.97
ri(m)	2.5	3.3	3.6	19.0	38.1	57.7	23.6	53.8	11.2	10.4	4.3	4.1
tamx(m)	-5.3	-3.2	2.9	13.2	20.6	25.6	28.8	27.4	22.3	15.9	4.7	-2.6
tamn(m)	-16.5	-15.0	-8.0	0.4	7.4	13.1	15.9	14.8	9.2	2.9	-5.7	-12.9
ra(m)	164.	256.	364.	422.	492.	531.	553.	482.	362.	233.	142.	120.

MISSOURI - COLUMBIA alat(deg)= 39.12 yrs= 29. elev (m)= 237.1 tp05(mm)= 67.3 tp6(mm)= 134.6

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.412	0.405	0.456	0.477	0.445	0.473	0.454	0.340	0.415	0.403	0.353	0.424
prw1(m)	0.181	0.224	0.274	0.309	0.279	0.279	0.243	0.205	0.199	0.182	0.163	0.208
alfg(m)	0.643	0.712	0.695	0.816	0.803	0.677	0.706	0.662	0.612	0.585	0.735	0.750
betg(m)	8.00	8.08	9.12	9.50	12.78	15.14	15.37	14.35	20.45	18.92	9.35	6.99
ri(m)	5.6	9.9	14.5	20.8	30.5	76.2	22.9	26.9	39.6	11.4	11.9	7.1
tamx(m)	4.1	6.2	11.1	18.4	23.8	29.1	32.1	31.2	27.1	21.1	11.8	5.8
tamn(m)	-5.9	-4.3	-0.1	6.6	12.2	17.6	19.8	19.0	14.3	8.5	0.7	-3.8
ra(m)	173.	251.	340.	434.	530.	574.	574.	522.	453.	322.	225.	158.

MISSOURI - KANSAS CITY alat(deg)= 39.12 yrs= 35. elev (m)= 226.2 tp05(mm)= 72.4 tp6(mm)= 146.1

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.364	0.304	0.438	0.485	0.439	0.450	0.393	0.443	0.448	0.464	0.357	0.381
prw1(m)	0.157	0.216	0.215	0.260	0.305	0.284	0.235	0.203	0.214	0.156	0.135	0.166
alfg(m)	0.727	0.713	0.682	0.754	0.687	0.786	0.672	0.646	0.662	0.695	0.553	0.859
betg(m)	6.58	7.32	11.18	11.53	14.73	16.61	19.89	18.69	19.81	16.08	13.23	6.05
ri(m)	5.6	8.1	19.0	27.9	26.4	21.8	30.0	36.8	33.0	29.0	13.2	20.3
tamx(m)	4.4	7.1	11.4	18.7	23.9	29.6	33.3	32.4	28.2	22.0	12.5	6.5
tamn(m)	-4.8	-2.9	1.1	7.7	13.3	19.2	21.7	20.7	15.5	9.3	1.4	-2.3
ra(m)	187.	259.	340.	428.	522.	546.	526.	521.	405.	287.	225.	151.

MISSOURI - ST LOUIS alat(deg)= 38.75 yrs= 11. elev (m)= 163.1 tp05(mm)= 63.5 tp6(mm)= 129.5

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.405	0.384	0.477	0.487	0.476	0.487	0.438	0.375	0.426	0.387	0.440	0.453
prw1(m)	0.195	0.254	0.276	0.328	0.273	0.243	0.224	0.201	0.190	0.184	0.193	0.218
alfg(m)	0.753	0.670	0.725	0.814	0.716	0.664	0.674	0.735	0.796	0.813	0.692	0.753
betg(m)	7.14	9.96	9.22	9.96	12.01	16.31	15.82	11.10	11.02	10.59	10.95	7.77
ri(m)	8.9	9.1	12.4	21.8	26.9	33.0	41.4	40.6	23.9	7.9	9.1	5.6
tamx(m)	4.6	6.7	11.6	18.8	23.9	29.5	31.8	30.7	27.4	21.2	12.1	6.1
tamn(m)	-4.7	-3.7	0.2	6.6	11.8	17.3	19.4	19.1	14.2	8.1	1.4	-3.1
ra(m)	173.	251.	340.	434.	530.	574.	574.	522.	453.	322.	225.	158.

MISSISSIPPI - JACKSON alat(deg)= 32.32 yrs= 18. elev (m)= 93.0 tp05(mm)= 74.9 tp6(mm)= 170.2

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.516	0.454	0.458	0.364	0.539	0.450	0.451	0.394	0.429	0.396	0.389	0.488
prw1(m)	0.262	0.287	0.258	0.267	0.170	0.205	0.289	0.246	0.174	0.126	0.217	0.267
alfg(m)	0.636	0.758	0.670	0.657	0.684	0.673	0.759	0.623	0.540	0.551	0.652	0.679
betg(m)	15.37	14.55	18.29	21.34	19.68	15.19	13.11	16.00	21.41	19.02	16.79	18.42
ri(m)	35.8	19.6	24.6	63.5	29.5	39.4	69.8	35.1	21.6	26.7	23.9	25.4
tamx(m)	14.8	16.4	20.1	24.4	28.7	33.0	34.2	33.9	31.5	26.5	19.6	15.2
tamn(m)	3.3	4.7	7.5	12.1	16.0	20.2	21.4	20.9	18.2	11.7	6.2	3.7
ra(m)	221.	273.	350.	452.	571.	562.	573.	524.	542.	369.	263.	219.

MONTANA - BILLINGS alat(deg)= 45.80 yrs= 36. elev (m)=1087.2 tp05(mm)= 34.3 tp6(mm)= 68.6

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.442	0.500	0.439	0.475	0.544	0.491	0.328	0.376	0.414	0.307	0.347	0.489
prw1(m)	0.198	0.184	0.241	0.233	0.270	0.314	0.177	0.170	0.165	0.160	0.166	0.139
alfg(m)	1.011	1.083	0.845	0.775	0.740	0.728	0.662	0.743	0.753	0.768	0.732	0.911
betg(m)	2.36	2.24	3.30	6.78	6.63	7.37	4.80	5.54	6.12	4.85	4.60	2.82
ri(m)	2.3	2.0	4.1	4.8	11.2	12.4	30.2	11.7	6.1	3.0	7.6	2.5
tamx(m)	0.7	2.2	6.3	14.1	20.1	24.4	31.4	29.6	23.1	16.4	7.2	3.7
tamn(m)	-10.5	-9.3	-4.4	1.4	7.4	12.3	16.0	14.8	8.5	2.9	-3.8	-7.7
ra(m)	150.	261.	372.	462.	563.	622.	624.	526.	432.	289.	172.	138.

MONTANA - GREAT FALLS alat(deg)= 47.48 yrs= 33. elev (m)=1116.2 tp05(mm)= 32.3 tp6(mm)= 61.0

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.526	0.490	0.478	0.490	0.523	0.564	0.383	0.457	0.428	0.393	0.453	0.481
prw1(m)	0.210	0.211	0.207	0.245	0.269	0.297	0.177	0.162	0.169	0.129	0.156	0.178
alfg(m)	0.923	0.913	1.067	0.738	0.675	0.692	0.818	0.731	0.787	0.914	0.899	1.070
betg(m)	2.87	2.82	2.46	4.90	8.61	9.04	5.11	5.66	4.67	3.84	3.35	2.18
ri(m)	4.1	2.5	2.3	4.6	5.6	25.1	21.8	14.0	5.6	3.8	3.0	1.8
tamx(m)	-0.2	1.1	5.1	12.9	18.7	22.7	29.3	27.7	21.8	15.2	6.8	2.1
tamn(m)	-10.8	-10.2	-6.6	-0.1	4.6	8.3	12.3	11.0	6.4	2.0	-4.2	-7.3
ra(m)	140.	232.	366.	434.	528.	583.	639.	532.	407.	264.	154.	112.

MONTANA - HAVRE alat(deg)= 48.55 yrs= 10. elev (m)= 787.6 tp05(mm)= 32.3 tp6(mm)= 67.3

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.503	0.481	0.317	0.449	0.457	0.500	0.433	0.424	0.433	0.273	0.394	0.453
prw1(m)	0.189	0.162	0.169	0.183	0.237	0.308	0.154	0.152	0.163	0.138	0.130	0.144
alfg(m)	1.170	1.429	1.002	0.883	0.747	0.712	0.781	0.669	0.752	0.765	0.940	1.144
betg(m)	1.35	1.09	1.63	4.55	5.74	7.42	6.88	6.96	5.23	4.22	2.41	1.45
ri(m)	1.0	2.5	3.0	3.0	14.7	10.4	11.7	12.7	2.8	7.6	1.8	2.0
tamx(m)	-4.3	-2.6	3.2	13.6	20.3	23.2	29.6	28.1	21.3	15.2	4.8	-0.4
tamn(m)	-15.8	-14.9	-8.9	-1.3	4.8	9.0	12.6	10.8	4.8	0.2	-7.7	-11.9
ra(m)	135.	227.	361.	429.	523.	578.	634.	527.	402.	259.	149.	107.

MONTANA - HELENA alat(deg)= 46.60 yrs= 30. elev (m)=1166.8 tp05(mm)= 30.5 tp6(mm)= 57.1

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.429	0.328	0.421	0.373	0.498	0.573	0.381	0.361	0.446	0.331	0.390	0.481
prw1(m)	0.215	0.184	0.200	0.249	0.260	0.266	0.180	0.207	0.147	0.159	0.185	0.183
alfg(m)	1.114	0.982	0.843	0.805	0.726	0.891	0.883	0.804	0.844	0.802	0.866	1.116
betg(m)	1.60	1.80	2.69	3.63	5.89	5.41	3.86	4.44	3.61	3.40	2.41	1.73
ri(m)	1.8	2.0	2.0	3.6	4.8	30.7	16.0	10.7	6.3	1.8	1.5	2.0
tamx(m)	-1.8	0.9	5.8	13.4	18.8	22.4	29.1	27.9	21.6	14.9	5.8	1.2
tamn(m)	-13.1	-10.7	-6.6	-0.8	4.4	8.1	11.3	10.1	5.1	0.2	-6.2	-9.9
ra(m)	142.	234.	368.	436.	530.	585.	641.	534.	409.	266.	156.	114.

MONTANA - KALISPELL alat(deg)= 48.20 yrs= 21. elev (m)= 903.7 tp05(mm)= 22.1 tp6(mm)= 54.6

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.658	0.567	0.539	0.429	0.518	0.563	0.310	0.510	0.525	0.540	0.525	0.570
prw1(m)	0.383	0.309	0.249	0.250	0.264	0.310	0.145	0.164	0.197	0.217	0.322	0.431
alfg(m)	0.998	1.027	1.055	0.834	0.862	0.807	0.829	0.798	0.866	0.968	0.857	0.921
betg(m)	2.54	2.06	1.75	3.43	4.70	6.30	4.72	5.56	4.14	2.90	3.35	2.79
ri(m)	2.0	1.8	3.6	4.1	7.6	14.5	8.6	30.5	10.2	2.5	2.0	2.5
tamx(m)	-2.4	1.1	5.7	13.6	19.1	22.5	28.7	27.3	21.2	13.3	4.1	-0.4
tamn(m)	-11.1	-9.5	-5.9	-0.6	3.3	7.1	8.7	7.2	4.0	-0.2	-5.2	-7.4
ra(m)	135.	227.	361.	429.	523.	578.	634.	527.	402.	259.	149.	107.

MONTANA - MILES CITY alat(deg)= 46.40 yrs= 33. elev (m)= 801.3 tp05(mm)= 43.9 tp6(mm)= 81.3

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.444	0.467	0.385	0.488	0.507	0.491	0.344	0.386	0.460	0.324	0.355	0.497
prw1(m)	0.212	0.193	0.200	0.213	0.262	0.309	0.230	0.166	0.146	0.135	0.159	0.168
alfg(m)	1.122	0.988	0.958	0.869	0.741	0.744	0.666	0.699	0.797	0.848	0.861	1.141
betg(m)	1.42	1.96	2.13	4.62	6.73	8.79	7.47	6.15	4.72	3.10	2.90	1.65
ri(m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tamx(m)	-2.6	-0.1	5.7	14.8	21.4	25.8	32.3	30.8	24.0	16.9	6.4	0.9
tamn(m)	-14.7	-12.9	-7.0	0.4	6.7	11.4	15.8	14.3	8.2	1.9	-5.7	-10.7
ra(m)	140.	232.	366.	434.	528.	583.	639.	532.	407.	264.	154.	112.

NEBRASKA - GRAND ISLAND alat(deg)= 40.97 yrs= 27. elev (m)= 561.1 tp05(mm)= 68.6 tp6(mm)= 123.2

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.409	0.422	0.413	0.514	0.474	0.500	0.353	0.383	0.441	0.308	0.250	0.287
prw1(m)	0.108	0.181	0.178	0.204	0.278	0.259	0.271	0.221	0.188	0.113	0.109	0.120
alfg(m)	0.841	0.795	0.745	0.645	0.724	0.745	0.668	0.647	0.650	0.885	0.780	0.676
betg(m)	3.05	3.94	5.69	11.20	12.14	13.87	12.09	12.73	11.96	6.68	4.04	5.13
ri(m)	1.3	7.4	6.1	30.5	31.0	19.3	13.7	31.0	76.2	8.1	7.6	2.0
tamx(m)	1.1	3.8	9.6	17.4	23.1	29.0	33.8	32.0	26.7	19.7	9.7	3.1
tamn(m)	-11.2	-8.6	-3.4	3.6	9.3	15.0	18.3	17.1	12.0	4.7	-3.4	-8.7
ra(m)	193.	264.	355.	421.	499.	549.	573.	489.	401.	300.	204.	164.

NEBRASKA - NORTH PLATTE alat(deg)= 41.13 yrs= 6. elev (m)= 847.0 tp05(mm)= 66.0 tp6(mm)= 111.8

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.292	0.377	0.344	0.448	0.498	0.453	0.377	0.314	0.435	0.351	0.309	0.268
prw1(m)	0.126	0.151	0.167	0.179	0.255	0.273	0.270	0.227	0.154	0.117	0.108	0.112
alfg(m)	0.845	0.750	0.731	0.683	0.700	0.635	0.769	0.676	0.705	0.704	0.813	0.785
betg(m)	2.39	3.48	4.83	8.71	11.84	16.26	10.19	9.86	10.36	7.16	3.33	3.20
ri(m)	1.5	1.0	23.4	14.7	36.6	19.6	52.8	30.5	27.4	3.6	5.1	2.0
tamx(m)	2.7	5.3	9.7	16.6	22.1	27.5	31.9	30.8	25.7	19.4	10.3	4.2
tamn(m)	-11.6	-9.0	-4.8	1.9	7.8	13.3	16.8	15.4	9.6	2.5	-4.9	-9.5
ra(m)	193.	264.	355.	421.	499.	549.	573.	489.	401.	300.	204.	164.

NEBRASKA - SCOTTSBLUFF alat(deg)= 41.87 yrs= 15. elev (m)=1204.0 tp05(mm)= 50.8 tp6(mm)= 90.2

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.326	0.396	0.390	0.474	0.555	0.529	0.335	0.323	0.446	0.363	0.286	0.354
prw1(m)	0.122	0.133	0.192	0.189	0.269	0.312	0.240	0.171	0.147	0.112	0.112	0.129
alfg(m)	0.998	0.998	0.877	0.858	0.715	0.699	0.676	0.789	0.600	0.720	0.868	0.998
betg(m)	1.75	1.65	2.90	4.98	8.71	10.11	8.48	4.67	7.09	5.92	2.54	2.13
ri(m)	1.5	1.8	6.3	4.8	13.0	30.5	41.1	26.9	6.3	3.3	5.1	2.3
tamx(m)	2.6	5.4	9.3	15.9	21.2	27.2	32.3	31.1	25.7	19.1	9.9	4.4
tamn(m)	-12.1	-9.7	-6.2	-0.2	5.7	11.1	15.0	13.8	7.8	1.5	-5.4	-9.9
ra(m)	216.	295.	424.	508.	554.	643.	606.	536.	438.	324.	229.	186.

NEVADA - ELKO alat(deg)= 40.83 yrs= 27. elev (m)=1546.9 tp05(mm)= 19.0 tp6(mm)= 40.6

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.467	0.533	0.420	0.476	0.532	0.547	0.310	0.354	0.250	0.338	0.496	0.489
prw1(m)	0.224	0.216	0.212	0.163	0.176	0.130	0.095	0.091	0.083	0.080	0.146	0.220
alfg(m)	0.797	0.928	0.958	0.905	0.960	0.809	0.828	0.565	0.779	0.738	0.998	0.921
betg(m)	4.17	2.31	2.74	2.92	2.97	4.80	2.90	7.87	3.33	4.90	3.15	3.40
ri(m)	2.0	2.3	3.0	4.6	3.0	7.6	11.7	2.5	8.9	3.0	2.5	2.5
tamx(m)	1.4	4.6	9.6	15.8	21.4	26.1	32.9	31.7	26.3	18.8	9.5	3.8
tamn(m)	-12.7	-8.6	-5.1	-1.8	1.9	5.3	9.5	7.8	2.4	-1.7	-6.8	-9.5
ra(m)	236.	339.	468.	563.	625.	712.	647.	618.	518.	394.	289.	218.

NEVADA - LAS VEGAS alat(deg)= 36.08 yrs= 21. elev (m)= 659.0 tp05(mm)= 26.7 tp6(mm)= 51.1

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.271	0.311	0.346	0.250	0.211	0.071	0.275	0.161	0.258	0.300	0.333	0.356
prw1(m)	0.061	0.065	0.055	0.048	0.025	0.022	0.067	0.082	0.040	0.041	0.056	0.047
alfg(m)	0.808	0.921	0.802	0.749	0.727	0.669	0.672	0.543	0.629	0.799	0.605	0.826
betg(m)	5.08	3.17	3.78	4.62	3.99	6.22	6.68	8.64	7.95	3.94	9.65	4.11
ri(m)	3.0	6.3	5.1	2.5	7.4	0.8	24.1	16.0	12.7	7.4	2.0	3.6
tamx(m)	13.0	16.7	20.5	25.9	31.1	37.2	40.8	39.6	35.7	27.6	19.5	14.5
tamn(m)	0.6	3.7	6.7	11.4	15.7	20.1	24.2	23.1	18.4	11.7	4.8	1.9
ra(m)	277.	384.	519.	621.	702.	748.	675.	627.	551.	429.	318.	258.

NEVADA - RENO alat(deg)= 39.50 yrs= 16. elev (m)=1340.2 tp05(mm)= 22.9 tp6(mm)= 63.5

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.496	0.454	0.380	0.349	0.414	0.386	0.294	0.420	0.297	0.250	0.500	0.484
prw1(m)	0.138	0.113	0.135	0.101	0.101	0.074	0.067	0.049	0.044	0.046	0.093	0.138
alfg(m)	0.728	0.748	0.838	0.721	0.663	0.942	0.998	0.900	0.960	0.701	0.813	0.718
betg(m)	6.99	6.55	3.81	4.62	6.43	3.51	2.41	2.72	4.01	5.92	4.22	6.73
ri(m)	4.1	3.0	2.8	1.8	3.0	2.0	5.8	9.4	3.0	3.8	3.0	4.1
tamx(m)	7.6	10.5	13.6	18.7	22.9	27.1	33.2	32.3	27.9	21.2	13.9	8.4
tamn(m)	-8.6	-5.8	-4.1	-0.9	2.9	5.6	8.5	7.1	3.7	-0.4	-4.8	-7.2
ra(m)	223.	316.	374.	551.	615.	691.	760.	681.	510.	357.	248.	182.

NEVADA - WINNEMUCCA alat(deg)= 40.90 yrs= 87. elev (m)=1310.3 tp05(mm)= 19.0 tp6(mm)= 36.8

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.467	0.426	0.443	0.351	0.448	0.554	0.243	0.289	0.340	0.385	0.496	0.473
prw1(m)	0.198	0.177	0.153	0.146	0.147	0.113	0.053	0.052	0.058	0.087	0.149	0.193
alfg(m)	0.928	0.961	0.998	0.786	0.899	0.718	0.787	0.759	0.783	0.761	0.998	0.930
betg(m)	3.12	2.92	2.39	4.37	3.51	5.69	2.69	4.88	3.61	4.55	3.12	3.02
ri(m)	3.3	2.8	2.5	4.6	5.3	8.6	3.0	8.1	4.8	6.9	2.5	3.3
tamx(m)	3.0	6.7	10.3	16.3	21.8	26.7	33.3	31.3	25.2	18.1	10.2	4.2
tamn(m)	-7.7	-3.9	-2.1	0.1	4.7	8.8	13.6	10.6	5.8	0.4	-3.9	-6.4
ra(m)	236.	339.	468.	563.	625.	712.	647.	618.	518.	394.	289.	218.

NEW HAMPSHIRE - CONCORD alat(deg)= 43.20 yrs= 87. elev (m)= 103.3 tp05(mm)= 49.5 tp6(mm)= 109.2

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.405	0.396	0.459	0.441	0.463	0.457	0.368	0.403	0.409	0.422	0.494	0.461
prw1(m)	0.300	0.307	0.295	0.321	0.317	0.296	0.298	0.295	0.241	0.211	0.333	0.293
alfg(m)	0.774	0.800	0.809	0.873	0.763	0.723	0.741	0.654	0.718	0.710	0.701	0.670
betg(m)	7.98	8.81	8.13	8.05	8.18	9.78	10.34	11.91	12.88	13.11	12.01	12.06
ri(m)	4.6	4.6	7.4	10.2	10.7	24.9	18.0	29.5	11.9	8.1	7.6	8.6
tamx(m)	-0.2	0.3	6.1	13.1	20.4	25.5	28.1	26.8	22.4	16.5	8.6	1.3
tamn(m)	-13.0	-12.3	-6.3	-0.9	4.8	10.1	12.9	11.6	7.3	1.3	-3.4	-10.2
ra(m)	122.	223.	243.	402.	453.	489.	503.	450.	354.	258.	173.	128.

NEW HAMPSHIRE - MOUNT WASHINGTON alat(deg)= 44.27 yrs= 25. elev (m)=1908.7 tp05(mm)= 43.7 tp6(mm)= 104.1

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.648	0.673	0.724	0.710	0.632	0.628	0.616	0.638	0.634	0.646	0.726	0.714
prw1(m)	0.524	0.569	0.441	0.436	0.397	0.439	0.473	0.416	0.409	0.313	0.495	0.537
alfg(m)	0.789	0.619	0.735	0.822	0.794	0.972	0.849	0.893	0.787	0.808	0.734	0.695
betg(m)	9.91	18.47	11.76	9.93	11.94	10.34	12.55	13.21	13.61	14.00	14.00	14.25
ri(m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tamx(m)	-9.9	-10.1	-6.9	-1.8	5.3	10.3	12.8	11.8	8.4	3.3	-3.1	-8.4
tamn(m)	-19.6	-19.4	-15.3	-9.3	-1.7	3.4	6.3	5.6	1.7	-3.7	-10.4	-17.2
ra(m)	117.	218.	238.	410.	455.	505.	500.	459.	290.	240.	135.	96.

NEW JERSEY - NEWARK alat(deg)= 40.70 yrs= 13. elev (m)= 2.1 tp05(mm)= 61.0 tp6(mm)= 133.3

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.437	0.398	0.470	0.463	0.473	0.407	0.448	0.432	0.426	0.378	0.450	0.461
prw1(m)	0.300	0.313	0.316	0.330	0.297	0.278	0.254	0.260	0.211	0.189	0.299	0.292
alfg(m)	0.781	0.763	0.704	0.738	0.719	0.736	0.630	0.616	0.600	0.691	0.720	0.738
betg(m)	7.90	10.64	12.73	11.02	10.08	9.58	15.34	17.30	16.74	14.83	11.40	10.69
ri(m)	7.9	11.7	7.9	15.2	20.6	20.1	22.9	37.8	21.6	15.0	25.4	10.2
tamx(m)	4.2	4.8	9.3	16.1	22.3	27.4	30.1	28.8	25.0	19.0	11.9	5.6
tamn(m)	-3.9	-4.1	0.1	5.4	11.1	16.2	19.2	18.3	14.2	8.3	2.9	-2.6
ra(m)	130.	199.	290.	369.	432.	470.	459.	389.	331.	242.	147.	115.

NEW MEXICO - ALBUQUERQUE alat(deg)= 35.05 yrs= 32. elev (m)=1618.8 tp05(mm)= 37.6 tp6(mm)= 77.5

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.263	0.392	0.346	0.264	0.346	0.412	0.395	0.429	0.320	0.378	0.339	0.350
prw1(m)	0.080	0.090	0.095	0.073	0.094	0.077	0.253	0.240	0.129	0.090	0.070	0.093
alfg(m)	0.840	0.998	0.964	0.712	0.699	0.718	0.744	0.804	0.836	0.739	0.998	0.858
betg(m)	2.84	2.57	3.15	5.21	3.53	5.41	5.31	4.85	4.62	7.47	2.82	3.96
ri(m)	4.3	2.3	3.0	7.6	12.7	24.9	13.0	14.5	9.1	17.5	3.0	4.1
tamx(m)	8.0	11.2	14.9	20.6	25.7	31.4	32.9	31.1	27.9	21.5	13.4	9.1
tamn(m)	-4.7	-2.5	0.4	5.7	11.1	16.2	18.8	17.9	14.2	7.4	-0.5	-3.6
ra(m)	303.	386.	511.	618.	686.	726.	683.	626.	554.	438.	334.	276.

NEW MEXICO - ROSWELL alat(deg)= 33.30 yrs= 24. elev (m)=1100.9 tp05(mm)= 52.1 tp6(mm)= 92.7

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.314	0.352	0.358	0.286	0.329	0.307	0.408	0.421	0.384	0.531	0.360	0.359
prw1(m)	0.063	0.097	0.072	0.056	0.091	0.117	0.197	0.173	0.125	0.078	0.053	0.070
alfg(m)	0.830	0.858	0.810	0.740	0.641	0.612	0.664	0.683	0.593	0.596	0.768	0.779
betg(m)	4.98	4.06	4.32	5.92	6.96	8.38	8.38	8.41	9.32	10.97	4.47	4.65
ri(m)	1.5	2.3	2.8	7.4	32.0	26.7	45.7	49.3	23.4	19.6	5.8	1.0
tamx(m)	12.8	15.8	20.4	26.1	30.4	35.3	35.2	34.1	30.6	24.9	18.3	13.8
tamn(m)	-6.3	-4.6	-1.1	3.9	9.6	14.8	16.5	15.4	11.3	5.1	-2.9	-6.1
ra(m)	313.	410.	527.	634.	694.	709.	646.	620.	556.	440.	352.	293.

NEW YORK - ALBANY alat(deg)= 42.58 yrs= 25. elev (m)= 83.8 tp05(mm)= 50.8 tp6(mm)= 114.3

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.456	0.441	0.471	0.519	0.516	0.461	0.391	0.358	0.360	0.425	0.474	0.494
prw1(m)	0.360	0.365	0.331	0.331	0.336	0.310	0.303	0.322	0.254	0.210	0.340	0.339
alfg(m)	0.755	0.683	0.747	0.708	0.673	0.741	0.695	0.705	0.672	0.709	0.788	0.673
betg(m)	5.89	7.47	8.20	8.46	9.45	8.56	9.80	10.13	14.12	11.73	7.92	9.09
ri(m)	11.2	5.3	14.5	5.6	16.5	33.0	50.3	18.8	21.8	15.2	10.7	5.6
tamx(m)	-0.6	0.3	5.5	13.7	20.8	25.9	28.7	27.4	22.7	16.6	8.6	1.4
tamn(m)	-9.8	-9.6	-4.4	2.1	7.9	13.2	15.8	14.7	10.2	4.3	-0.8	-7.5
ra(m)	135.	205.	278.	343.	418.	453.	446.	402.	304.	223.	133.	109.

NEW YORK - BUFFALO alat(deg)= 42.93 yrs= 28. elev (m)= 214.9 tp05(mm)= 41.9 tp6(mm)= 91.4

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.704	0.658	0.613	0.595	0.483	0.397	0.363	0.446	0.480	0.555	0.630	0.699
prw1(m)	0.578	0.485	0.421	0.409	0.339	0.276	0.283	0.300	0.270	0.239	0.412	0.533
alfg(m)	0.779	0.728	0.752	0.783	0.757	0.785	0.719	0.754	0.728	0.711	0.824	0.751
betg(m)	4.78	5.16	5.99	6.86	8.03	7.80	10.64	11.71	10.34	9.50	7.29	5.21
ri(m)	4.8	6.1	9.7	19.8	17.8	17.5	24.1	35.6	26.7	12.4	7.4	4.8
tamx(m)	-0.7	-0.6	3.7	11.6	18.6	23.9	26.7	25.9	21.9	15.6	8.1	1.3
tamn(m)	-7.7	-8.2	-4.2	1.1	6.7	12.5	15.2	14.5	10.7	5.2	-0.2	-6.1
ra(m)	121.	179.	298.	282.	498.	558.	558.	490.	274.	285.	137.	111.

NEW YORK - NEW YORK alat(deg)= 40.60 yrs=103. elev (m)= 40.2 tp05(mm)= 61.0 tp6(mm)= 133.3

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.464	0.446	0.466	0.471	0.443	0.416	0.381	0.358	0.399	0.396	0.479	0.473
prw1(m)	0.302	0.296	0.325	0.354	0.314	0.271	0.245	0.297	0.217	0.191	0.283	0.299
alfg(m)	0.739	0.671	0.683	0.650	0.664	0.765	0.627	0.583	0.667	0.608	0.683	0.658
betg(m)	8.33	12.50	12.93	12.55	10.49	9.65	15.95	19.51	14.71	17.32	13.06	12.22
ri(m)	26.7	10.9	10.4	9.1	18.5	26.7	30.2	31.2	31.8	11.9	14.0	13.5
tamx(m)	4.2	4.6	8.8	15.3	21.9	26.8	29.6	28.5	24.9	19.1	12.1	5.6
tamn(m)	-2.8	-3.1	0.7	6.2	11.9	16.9	20.1	19.3	15.6	10.2	4.6	-1.3
ra(m)	130.	199.	290.	369.	432.	470.	459.	389.	331.	242.	147.	115.

NEW YORK - SYRACRUSE alat(deg)= 43.12 yrs= 22. elev (m)= 125.0 tp05(mm)= 61.0 tp6(mm)= 96.5

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.655	0.657	0.631	0.583	0.510	0.413	0.445	0.399	0.467	0.532	0.608	0.674
prw1(m)	0.494	0.487	0.415	0.388	0.350	0.301	0.284	0.308	0.262	0.266	0.425	0.561
alfg(m)	0.893	0.778	0.736	0.800	0.783	0.735	0.715	0.722	0.805	0.824	0.806	0.840
betg(m)	4.09	5.64	6.20	6.78	7.11	9.60	10.59	12.17	8.25	8.23	6.50	4.72
ri(m)	7.4	4.6	7.6	13.2	24.9	32.5	29.0	29.7	20.3	12.7	6.9	4.8
tamx(m)	-0.3	-0.1	4.6	12.8	19.9	25.4	28.0	26.9	22.4	16.2	8.4	1.4
tamn(m)	-8.6	-8.5	-3.9	2.7	8.6	13.8	16.7	15.5	11.3	5.8	0.7	-6.2
ra(m)	114.	192.	270.	332.	438.	499.	513.	451.	344.	229.	118.	94.

NORTH CAROLINA - ASHEVILLE alat(deg)= 35.43 yrs= 5. elev (m)= 652.3 tp05(mm)= 64.8 tp6(mm)= 165.1

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.448	0.507	0.519	0.520	0.535	0.498	0.551	0.542	0.532	0.582	0.450	0.492
prw1(m)	0.265	0.302	0.344	0.296	0.265	0.296	0.358	0.279	0.184	0.158	0.221	0.239
alfg(m)	0.690	0.786	0.700	0.670	0.772	0.779	0.818	0.676	0.628	0.672	0.670	0.645
betg(m)	9.60	9.70	11.30	11.48	8.10	10.11	7.16	12.47	16.00	12.32	10.80	11.05
ri(m)	10.2	8.9	16.5	37.3	36.3	29.2	38.4	33.8	50.8	15.5	23.6	10.9
tamx(m)	8.6	9.7	13.4	19.5	24.2	27.8	28.6	28.1	25.3	20.2	13.5	9.1
tamn(m)	-2.4	-2.3	0.6	5.6	10.2	14.5	16.3	15.8	12.3	6.2	0.4	-2.6
ra(m)	208.	284.	362.	477.	539.	572.	552.	497.	414.	330.	251.	205.

NORTH CAROLINA - GREENSBORO alat(deg)= 36.08 yrs= 30. elev (m)= 273.4 tp05(mm)= 69.8 tp6(mm)= 137.2

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.435	0.500	0.516	0.442	0.502	0.495	0.519	0.539	0.476	0.479	0.436	0.434
prw1(m)	0.255	0.281	0.264	0.279	0.232	0.266	0.301	0.244	0.167	0.158	0.199	0.202
alfg(m)	0.739	0.819	0.803	0.725	0.721	0.646	0.694	0.643	0.535	0.562	0.697	0.713
betg(m)	11.66	11.10	10.82	11.81	9.88	15.95	12.70	16.43	19.51	19.53	11.43	14.76
ri(m)	15.2	9.1	13.7	11.7	20.6	25.1	54.6	31.8	41.9	15.2	14.0	10.7
tamx(m)	9.8	11.0	14.9	20.7	26.0	30.1	30.9	30.2	27.2	21.9	15.4	10.1
tamn(m)	-1.2	-1.0	2.1	7.4	12.7	17.4	19.4	18.8	15.2	8.3	2.2	-1.3
ra(m)	200.	276.	354.	469.	531.	564.	544.	485.	406.	322.	243.	197.

NORTH CAROLINA - RALEIGH alat(deg)= 35.87 yrs= 25. elev (m)= 132.3 tp05(mm)= 74.9 tp6(mm)= 149.9

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.416	0.508	0.465	0.433	0.442	0.459	0.521	0.480	0.431	0.400	0.418	0.425
prw1(m)	0.251	0.258	0.261	0.247	0.247	0.236	0.264	0.243	0.147	0.150	0.201	0.204
alfg(m)	0.722	0.808	0.873	0.844	0.797	0.732	0.770	0.620	0.729	0.722	0.755	0.850
betg(m)	12.32	11.53	9.91	10.29	10.87	13.74	14.50	20.65	16.33	15.04	12.01	11.02
ri(m)	12.4	14.0	18.5	12.7	22.1	57.1	24.4	24.4	23.9	23.9	22.9	30.0
tamx(m)	11.1	12.2	16.2	22.1	26.3	30.2	31.2	30.6	27.8	22.7	16.8	11.3
tamn(m)	-0.4	-0.1	3.2	8.2	13.2	17.7	19.8	19.3	15.8	9.0	3.2	-0.3
ra(m)	235.	302.	360.	466.	494.	564.	535.	476.	379.	307.	235.	199.

NORTH DAKOTA - BISMARCK alat(deg)= 46.77 yrs= 18. elev (m)= 502.9 tp05(mm)= 54.6 tp6(mm)= 95.3

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.354	0.393	0.372	0.477	0.480	0.519	0.412	0.330	0.344	0.363	0.445	0.437
prw1(m)	0.227	0.188	0.205	0.187	0.261	0.328	0.249	0.277	0.200	0.112	0.139	0.197
alfg(m)	1.184	0.935	0.803	0.704	0.698	0.673	0.690	0.626	0.755	0.822	0.828	1.076
betg(m)	1.42	1.88	2.54	6.35	8.33	10.72	8.53	8.15	5.74	4.01	2.74	1.45
ri(m)	1.8	1.8	3.3	7.1	18.0	13.5	23.9	20.1	25.1	3.3	1.5	2.8
tamx(m)	-6.6	-4.8	2.6	12.6	19.6	24.6	29.7	28.5	22.2	14.7	3.5	-3.6
tamn(m)	-18.8	-16.6	-8.6	-0.2	5.7	11.2	14.8	12.9	7.2	0.5	-7.5	-14.7
ra(m)	157.	250.	356.	447.	550.	590.	617.	516.	390.	272.	161.	124.

NORTH DAKOTA - WILLISTON alat(deg)= 48.18 yrs= 41. elev (m)= 572.1 tp05(mm)= 46.2 tp6(mm)= 86.4

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.409	0.374	0.349	0.397	0.469	0.480	0.396	0.297	0.383	0.364	0.393	0.469
prw1(m)	0.227	0.204	0.206	0.187	0.189	0.322	0.240	0.205	0.176	0.119	0.155	0.169
alfg(m)	1.006	1.009	1.117	0.731	0.728	0.689	0.644	0.644	0.664	0.733	1.038	1.115
betg(m)	1.78	1.96	1.47	6.38	7.29	9.14	8.76	8.28	6.96	4.55	1.98	1.52
ri(m)	24.1	16.5	26.9	31.8	21.8	45.7	72.4	38.4	39.9	16.8	22.4	16.3
tamx(m)	-6.8	-4.8	2.2	12.2	19.0	23.3	28.6	27.3	20.9	13.9	2.9	-4.0
tamn(m)	-17.7	-15.7	-8.3	-0.1	6.1	11.2	14.6	12.7	7.0	1.1	-7.1	-14.1
ra(m)	156.	254.	372.	451.	559.	598.	623.	524.	398.	269.	159.	120.

OHIO - CLEVELAND alat(deg)= 41.42 yrs= 16. elev (m)= 239.9 tp05(mm)= 49.5 tp6(mm)= 91.4

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.598	0.606	0.583	0.584	0.506	0.438	0.395	0.384	0.429	0.505	0.613	0.626
prw1(m)	0.470	0.452	0.432	0.404	0.319	0.290	0.292	0.267	0.252	0.244	0.352	0.419
alfg(m)	0.702	0.781	0.780	0.811	0.794	0.769	0.639	0.691	0.823	0.775	0.748	0.762
betg(m)	5.56	4.55	5.97	7.67	8.41	9.63	13.21	11.56	8.84	8.23	6.78	5.00
ri(m)	4.8	9.1	7.1	13.5	19.6	37.6	33.3	28.4	17.0	8.6	5.8	5.8
tamx(m)	2.2	2.4	7.3	13.9	21.1	26.9	29.3	28.2	24.3	17.9	9.6	3.1
tamn(m)	-6.2	-6.2	-2.1	3.1	9.0	14.6	17.0	16.2	12.8	6.9	1.2	-4.3
ra(m)	125.	183.	303.	286.	502.	562.	562.	494.	278.	289.	141.	115.

OHIO - COLUMBUS alat(deg)= 40.00 yrs= 79. elev (m)= 248.4 tp05(mm)= 54.6 tp6(mm)= 96.5

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.504	0.480	0.516	0.545	0.500	0.463	0.391	0.350	0.418	0.423	0.509	0.502
prw1(m)	0.339	0.359	0.384	0.360	0.328	0.276	0.323	0.230	0.216	0.205	0.288	0.329
alfg(m)	0.683	0.757	0.664	0.788	0.754	0.733	0.720	0.822	0.766	0.879	0.740	0.739
betg(m)	8.25	6.68	9.12	9.09	10.74	12.42	13.79	10.64	9.58	6.40	7.85	6.78
ri(m)	5.6	8.4	13.0	10.4	19.3	27.7	40.9	33.0	21.1	6.6	16.8	5.6
tamx(m)	3.2	4.2	9.7	16.3	22.5	27.9	30.1	28.9	25.7	18.9	10.4	4.1
tamn(m)	-5.8	-5.1	-1.1	3.8	9.5	15.1	17.0	16.0	12.6	6.1	0.6	-4.5
ra(m)	128.	200.	297.	391.	471.	562.	542.	477.	422.	286.	176.	129.

OHIO - TOLEDO alat(deg)= 41.58 yrs= 87. elev (m)= 206.0 tp05(mm)= 50.3 tp6(mm)= 90.2

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.534	0.450	0.515	0.520	0.519	0.459	0.392	0.364	0.433	0.431	0.505	0.521
prw1(m)	0.350	0.326	0.364	0.366	0.287	0.252	0.260	0.229	0.251	0.186	0.279	0.363
alfg(m)	0.656	0.752	0.724	0.745	0.802	0.763	0.716	0.737	0.755	0.674	0.759	0.640
betg(m)	6.10	5.79	6.38	7.75	7.95	11.02	12.80	12.90	8.15	9.68	7.29	7.19
ri(m)	5.3	10.7	8.9	8.6	16.3	25.9	16.3	27.2	14.0	11.9	8.1	11.9
tamx(m)	1.5	2.2	7.6	14.4	21.3	27.1	29.6	28.3	24.4	17.7	9.4	2.7
tamn(m)	-7.8	-7.4	-3.3	1.7	7.8	13.6	16.1	14.9	11.4	5.3	-0.7	-6.2
ra(m)	126.	204.	302.	386.	468.	544.	561.	487.	382.	275.	144.	109.

OKLAHOMA - OKLAHOMA CITY alat(deg)= 35.40 yrs= 30. elev (m)= 391.7 tp05(mm)= 81.3 tp6(mm)= 158.8

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.370	0.415	0.450	0.399	0.492	0.447	0.407	0.328	0.360	0.374	0.424	0.396
prw1(m)	0.123	0.172	0.179	0.197	0.217	0.205	0.175	0.190	0.190	0.117	0.100	0.125
alfg(m)	0.703	0.744	0.669	0.660	0.632	0.664	0.707	0.696	0.608	0.638	0.616	0.644
betg(m)	6.27	6.48	9.83	16.21	22.17	17.68	14.53	14.00	22.35	22.02	13.44	8.92
ri(m)	8.1	11.4	28.4	25.1	42.4	55.4	39.1	28.4	31.8	22.9	26.7	6.9
tamx(m)	7.7	10.7	15.3	21.4	25.6	30.8	33.8	34.2	29.3	23.3	14.9	9.6
tamn(m)	-2.2	-0.4	3.1	9.5	14.8	20.3	22.3	22.2	17.2	11.0	3.3	-0.3
ra(m)	251.	319.	409.	494.	536.	615.	610.	593.	487.	377.	291.	240.

OKLAHOMA - TULSA alat(deg)= 36.18 yrs= 31. elev (m)= 198.1 tp05(mm)= 81.3 tp6(mm)= 160.0

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.404	0.438	0.414	0.461	0.483	0.413	0.422	0.326	0.399	0.427	0.392	0.422
prw1(m)	0.146	0.184	0.205	0.231	0.260	0.217	0.186	0.171	0.193	0.133	0.146	0.165
alfg(m)	0.711	0.757	0.672	0.707	0.658	0.647	0.591	0.662	0.638	0.582	0.605	0.625
betg(m)	7.65	7.80	12.55	16.00	16.81	19.23	23.09	16.81	20.73	23.16	13.89	9.70
ri(m)	7.6	8.1	25.7	27.4	33.0	32.0	36.3	35.6	33.0	31.8	37.3	17.0
tamx(m)	7.7	10.9	15.6	21.4	25.5	30.7	33.8	33.9	29.8	23.9	14.8	9.4
tamn(m)	-3.1	-1.3	2.3	8.4	14.3	19.6	21.9	21.1	16.6	10.3	2.5	-1.0
ra(m)	205.	289.	390.	454.	504.	600.	596.	545.	455.	354.	269.	209.

OREGON - BURNS alat(deg)= 43.58 yrs= 21. elev (m)=1261.9 tp05(mm)= 21.6 tp6(mm)= 38.1

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.566	0.519	0.545	0.438	0.468	0.433	0.255	0.352	0.339	0.508	0.596	0.606
prw1(m)	0.353	0.223	0.233	0.178	0.180	0.157	0.067	0.082	0.072	0.127	0.201	0.243
alfg(m)	0.910	0.890	0.998	0.927	0.986	0.930	0.868	0.792	0.657	0.738	0.998	0.897
betg(m)	3.86	3.61	2.44	2.72	3.20	3.53	3.76	4.17	6.68	5.16	3.71	4.27
ri(m)	3.0	1.8	3.8	5.1	4.6	5.1	7.1	4.1	2.5	2.8	2.0	2.0
tamx(m)	1.9	5.5	10.8	16.1	20.7	24.3	30.7	29.4	24.5	17.6	9.6	3.4
tamn(m)	-11.0	-6.4	-3.2	0.1	3.8	7.4	11.2	9.7	4.7	-0.7	-4.7	-8.3
ra(m)	138.	236.	342.	485.	585.	636.	670.	576.	460.	301.	182.	124.

OREGON - MEACHUM alat(deg)= 45.50 yrs= 13. elev (m)=1234.4 tp05(mm)= 25.4 tp6(mm)= 27.7

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.737	0.729	0.713	0.663	0.610	0.556	0.299	0.536	0.521	0.633	0.721	0.716
prw1(m)	0.484	0.331	0.311	0.291	0.270	0.216	0.080	0.100	0.129	0.194	0.298	0.371
alfg(m)	0.844	0.900	0.998	0.919	0.920	0.838	0.816	0.688	0.792	0.801	0.927	0.906
betg(m)	7.09	5.89	4.67	5.33	4.88	5.69	4.37	6.83	7.72	7.80	6.91	7.14
ri(m)	3.6	2.8	2.0	6.6	1.0	3.6	17.8	0.5	3.6	2.5	5.3	3.3
tamx(m)	0.0	2.3	5.5	10.5	14.9	18.7	25.2	24.6	19.8	13.1	5.8	1.7
tamn(m)	-7.9	-5.7	-3.3	-0.4	2.8	5.8	9.4	9.4	6.5	1.9	-2.6	-4.9
ra(m)	117.	222.	351.	521.	616.	680.	707.	604.	458.	274.	136.	100.

OREGON - MEDFORD alat(deg)= 42.37 yrs= 28. elev (m)= 399.9 tp05(mm)= 26.7 tp6(mm)= 76.2

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.655	0.557	0.588	0.534	0.538	0.452	0.344	0.367	0.318	0.529	0.627	0.657
prw1(m)	0.361	0.269	0.236	0.189	0.174	0.111	0.036	0.053	0.086	0.159	0.273	0.281
alfg(m)	0.703	0.608	0.876	0.946	0.791	0.985	0.579	0.998	0.724	0.678	0.692	0.654
betg(m)	8.79	8.74	4.42	2.82	4.83	3.51	7.52	3.89	6.30	8.56	8.76	10.72
ri(m)	3.8	4.6	5.6	9.9	12.4	7.4	4.8	9.9	7.6	4.3	4.1	6.9
tamx(m)	7.0	11.1	15.1	18.7	22.9	26.6	31.6	31.5	27.6	20.2	12.3	7.3
tamn(m)	-1.2	0.7	1.8	3.8	6.8	9.9	12.6	11.9	8.4	4.7	1.2	-0.1
ra(m)	116.	215.	336.	482.	592.	652.	698.	605.	447.	279.	149.	93.

OREGON - PENDLETON alat(deg)= 45.68 yrs= 22. elev (m)= 454.8 tp05(mm)= 26.7 tp6(mm)= 63.5

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.571	0.535	0.485	0.434	0.452	0.364	0.232	0.391	0.383	0.462	0.521	0.551
prw1(m)	0.353	0.247	0.250	0.249	0.179	0.163	0.067	0.078	0.108	0.174	0.275	0.369
alfg(m)	0.966	0.977	0.998	0.938	0.874	0.843	0.957	0.932	0.913	0.813	0.933	0.909
betg(m)	3.40	2.82	2.54	2.74	4.14	3.68	2.44	2.82	3.78	3.96	3.53	3.02
ri(m)	2.0	4.1	5.3	3.6	4.1	3.8	16.8	19.0	4.8	2.8	3.8	5.1
tamx(m)	2.7	6.9	12.5	17.3	22.3	26.2	31.7	30.4	25.1	17.7	8.4	5.2
tamn(m)	-4.3	-1.8	2.1	5.2	8.6	12.3	15.5	14.7	11.1	6.2	1.7	-1.6
ra(m)	117.	222.	351.	521.	616.	680.	707.	604.	458.	274.	136.	100.

OREGON - PORTLAND alat(deg)= 45.60 yrs= 55. elev (m)= 9.1 tp05(mm)= 25.4 tp6(mm)= 104.1

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.802	0.697	0.726	0.634	0.619	0.561	0.386	0.585	0.497	0.684	0.775	0.752
prw1(m)	0.425	0.357	0.344	0.309	0.236	0.188	0.071	0.082	0.172	0.232	0.324	0.443
alfg(m)	0.830	0.840	0.998	0.945	0.853	0.854	0.788	0.843	0.790	0.962	0.869	0.879
betg(m)	9.37	7.70	5.36	4.50	4.98	5.26	3.66	5.69	6.07	6.83	8.71	8.94
ri(m)	7.9	9.1	4.3	5.6	10.4	11.2	9.4	9.7	6.3	6.1	5.6	6.1
tamx(m)	6.8	9.7	13.1	16.8	20.3	22.8	26.2	26.0	23.0	17.5	11.5	8.2
tamn(m)	1.5	3.3	5.1	7.2	9.8	12.4	14.3	14.4	12.4	9.3	5.4	3.3
ra(m)	92.	164.	272.	377.	494.	471.	541.	463.	356.	211.	113.	81.

OREGON - SALEM alat(deg)= 44.92 yrs= 20. elev (m)= 59.4 tp05(mm)= 26.2 tp6(mm)= 106.7

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.791	0.728	0.750	0.638	0.611	0.555	0.404	0.494	0.507	0.659	0.776	0.755
prw1(m)	0.411	0.341	0.293	0.304	0.215	0.151	0.045	0.086	0.148	0.233	0.339	0.427
alfg(m)	0.866	0.763	0.964	0.867	0.998	0.776	0.826	0.829	0.722	0.866	0.833	0.827
betg(m)	11.05	9.65	6.86	5.03	4.37	5.61	3.76	3.99	7.52	8.56	9.65	11.02
ri(m)	6.3	6.1	6.9	4.3	9.7	8.4	5.6	5.8	6.1	6.3	7.4	6.9
tamx(m)	7.1	10.2	13.3	16.8	20.9	24.6	28.4	27.9	24.7	18.1	11.6	8.3
tamn(m)	-0.1	1.7	3.1	4.7	7.1	9.7	11.2	10.9	9.1	6.8	3.3	1.7
ra(m)	89.	135.	287.	406.	517.	570.	676.	558.	397.	235.	144.	80.

OREGON - SEXTON SUMMIT alat(deg)= 42.62 yrs= 16. elev (m)=1169.2 tp05(mm)= 30.5 tp6(mm)= 127.0

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.774	0.689	0.712	0.604	0.602	0.476	0.212	0.426	0.489	0.632	0.719	0.745
prw1(m)	0.373	0.312	0.300	0.230	0.179	0.126	0.044	0.053	0.101	0.174	0.276	0.286
alfg(m)	0.730	0.712	0.887	0.835	0.776	0.890	0.819	0.749	0.745	0.729	0.694	0.731
betg(m)	13.54	10.90	6.65	5.66	7.04	4.85	4.39	6.71	7.75	11.30	14.66	14.20
ri(m)	5.6	3.6	21.6	5.1	7.1	48.5	4.8	15.7	10.9	7.6	7.1	6.6
tamx(m)	5.3	5.8	8.4	12.4	16.6	19.9	24.7	25.0	21.5	14.9	8.4	5.7
tamn(m)	-1.1	-0.9	-0.4	1.2	3.9	6.8	10.0	10.2	9.4	5.4	1.8	-0.5
ra(m)	116.	215.	336.	482.	592.	652.	698.	605.	447.	279.	149.	93.

PENNSYLVANIA - PHILADELPIA alat(deg)= 39.88 yrs= 28. elev (m)= 1.5 tp05(mm)= 63.5 tp6(mm)= 132.1

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.464	0.393	0.438	0.459	0.437	0.395	0.372	0.421	0.407	0.381	0.441	0.478
prw1(m)	0.268	0.295	0.298	0.313	0.275	0.272	0.246	0.256	0.185	0.171	0.257	0.255
alfg(m)	0.749	0.757	0.811	0.759	0.760	0.585	0.664	0.668	0.613	0.577	0.735	0.673
betg(m)	8.69	9.86	11.23	10.29	9.27	17.37	16.89	15.62	18.95	17.22	11.86	12.75
ri(m)	8.9	8.6	11.2	13.7	16.0	30.0	37.8	29.5	21.3	11.2	13.7	8.9
tamx(m)	4.6	5.4	10.2	17.0	23.0	27.6	29.9	28.7	25.1	19.2	12.2	5.7
tamn(m)	-4.3	-4.1	-0.2	5.2	11.0	15.8	18.4	17.5	13.4	7.2	1.4	-3.6
ra(m)	157.	227.	318.	403.	482.	527.	509.	455.	385.	278.	192.	140.

PENNSYLVANIA - PITTSBURGH alat(deg)= 40.50 yrs= 18. elev (m)= 346.6 tp05(mm)= 51.3 tp6(mm)= 97.8

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.596	0.606	0.582	0.526	0.516	0.486	0.400	0.360	0.391	0.443	0.565	0.608
prw1(m)	0.443	0.414	0.451	0.393	0.311	0.304	0.317	0.267	0.219	0.255	0.328	0.451
alfg(m)	0.751	0.836	0.731	0.847	0.772	0.733	0.728	0.651	0.723	0.695	0.841	0.765
betg(m)	5.71	5.00	7.70	7.92	9.37	10.90	11.81	13.46	10.21	9.07	5.46	4.78
ri(m)	8.9	5.6	10.7	9.7	17.0	20.1	36.1	37.6	20.3	21.1	6.3	6.1
tamx(m)	2.5	3.1	7.8	15.6	21.9	26.6	28.5	27.7	24.2	17.6	9.7	3.4
tamn(m)	-6.0	-6.3	-2.6	3.3	8.9	13.8	16.1	15.3	11.6	5.8	0.0	-4.9
ra(m)	94.	169.	216.	317.	429.	491.	497.	409.	339.	207.	118.	77.

RHODE ISLAND - PROVIDENCE alat(deg)= 41.73 yrs= 53. elev (m)= 16.8 tp05(mm)= 59.7 tp6(mm)= 124.5

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.422	0.461	0.453	0.484	0.445	0.465	0.354	0.372	0.400	0.405	0.495	0.450
prw1(m)	0.336	0.323	0.321	0.298	0.301	0.297	0.256	0.304	0.211	0.208	0.292	0.329
alfg(m)	0.650	0.637	0.657	0.658	0.670	0.650	0.655	0.589	0.636	0.590	0.626	0.645
betg(m)	12.12	14.43	14.27	13.94	11.46	9.42	12.47	16.26	17.35	18.67	16.08	15.04
ri(m)	9.7	9.1	7.6	7.9	14.7	19.3	37.8	33.0	21.1	31.5	11.4	9.4
tamx(m)	2.7	2.7	7.2	12.7	19.1	23.9	26.7	25.8	22.2	16.7	10.5	4.1
tamn(m)	-6.3	-6.4	-1.9	2.9	8.5	13.4	16.6	15.7	11.8	6.3	1.2	-4.6
ra(m)	155.	232.	334.	405.	477.	527.	513.	455.	377.	271.	176.	139.

SOUTH CAROLINA - CHARLESTON alat(deg)= 32.90 yrs= 27. elev (m)= 12.2 tp05(mm)= 80.0 tp6(mm)= 148.6

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.438	0.448	0.478	0.377	0.443	0.569	0.539	0.520	0.481	0.472	0.383	0.404
prw1(m)	0.244	0.268	0.265	0.194	0.205	0.259	0.381	0.310	0.231	0.134	0.171	0.222
alfg(m)	0.702	0.760	0.707	0.710	0.628	0.603	0.710	0.677	0.758	0.576	0.657	0.678
betg(m)	12.14	12.85	15.34	14.00	19.02	23.90	21.34	19.13	17.37	22.71	11.10	12.73
ri(m)	15.2	13.2	17.5	13.2	32.3	62.7	41.1	37.8	30.2	33.0	21.8	18.0
tamx(m)	16.2	16.9	20.0	24.9	28.8	31.8	31.8	31.6	29.4	25.1	19.9	16.3
tamn(m)	3.5	4.7	7.4	11.5	16.6	20.6	22.2	21.4	19.0	12.8	6.6	3.7
ra(m)	252.	314.	388.	512.	551.	564.	520.	501.	404.	338.	286.	225.

SOUTH CAROLINA - COLUMBIA alat(deg)= 33.95 yrs= 22. elev (m)= 64.9 tp05(mm)= 72.4 tp6(mm)= 177.8

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.492	0.477	0.481	0.449	0.417	0.446	0.515	0.502	0.462	0.529	0.392	0.416
prw1(m)	0.227	0.283	0.262	0.227	0.206	0.246	0.290	0.260	0.162	0.112	0.168	0.229
alfg(m)	0.649	0.731	0.758	0.674	0.758	0.812	0.672	0.637	0.559	0.578	0.723	0.737
betg(m)	15.54	14.20	15.06	16.10	14.76	12.06	17.17	21.26	26.19	20.93	12.01	12.88
ri(m)	13.2	19.8	30.5	27.4	40.1	45.7	38.1	45.0	49.0	20.8	17.5	8.9
tamx(m)	14.6	15.8	19.2	24.6	29.3	33.1	33.6	32.9	30.1	25.2	19.3	14.6
tamn(m)	2.0	2.4	5.7	10.3	15.3	19.9	21.5	20.9	18.1	11.1	4.8	1.4
ra(m)	247.	309.	383.	507.	546.	559.	515.	496.	399.	333.	281.	220.

SOUTH DAKOTA - HURON alat(deg)= 44.38 yrs= 18. elev (m)= 390.8 tp05(mm)= 63.0 tp6(mm)= 106.7

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.333	0.445	0.379	0.457	0.485	0.465	0.358	0.360	0.368	0.433	0.368	0.331
prw1(m)	0.171	0.167	0.189	0.252	0.263	0.324	0.261	0.254	0.176	0.114	0.134	0.169
alfg(m)	0.998	0.707	0.712	0.682	0.616	0.652	0.664	0.615	0.705	0.611	0.699	0.761
betg(m)	1.40	4.60	4.70	7.62	10.82	13.06	9.86	9.93	8.18	10.64	4.44	3.23
ri(m)	1.5	4.3	4.6	13.5	12.2	11.9	18.8	16.5	16.3	16.5	5.6	1.0
tamx(m)	-4.0	-2.0	6.2	15.3	22.0	27.2	31.9	30.6	25.1	17.8	6.6	-1.0
tamn(m)	-16.6	-14.1	-6.5	0.7	6.9	13.0	16.3	14.8	9.1	2.1	-6.1	-12.8
ra(m)	173.	267.	390.	472.	522.	575.	580.	531.	425.	305.	194.	148.

SOUTH DAKOTA - RAPID CITY alat(deg)= 44.05 yrs= 15. elev (m)= 964.7 tp05(mm)= 53.3 tp6(mm)= 90.2

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.370	0.503	0.444	0.518	0.519	0.557	0.394	0.338	0.362	0.360	0.382	0.411
prw1(m)	0.156	0.200	0.222	0.233	0.306	0.317	0.239	0.208	0.167	0.103	0.157	0.155
alfg(m)	0.998	0.988	0.815	0.776	0.674	0.713	0.622	0.757	0.709	0.782	0.830	0.998
betg(m)	1.63	2.24	3.30	6.68	8.79	9.60	9.91	6.38	6.35	5.11	2.49	1.78
ri(m)	1.3	1.3	3.8	6.3	8.9	22.9	30.2	26.2	6.1	20.3	1.8	1.5
tamx(m)	0.6	2.0	5.8	13.7	19.2	24.2	29.9	29.2	23.4	16.6	8.2	2.9
tamn(m)	-12.7	-11.0	-6.6	0.2	5.9	10.9	14.9	14.0	8.2	2.4	-4.6	-9.9
ra(m)	183.	277.	400.	482.	532.	585.	590.	541.	435.	315.	204.	158.

TENNESSEE - CHATTONOOGA alat(deg)= 35.03 yrs= 79. elev (m)= 204.2 tp05(mm)= 64.0 tp6(mm)= 130.8

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.513	0.517	0.489	0.493	0.473	0.465	0.541	0.457	0.443	0.489	0.453	0.453
prw1(m)	0.268	0.295	0.289	0.270	0.228	0.264	0.263	0.240	0.201	0.154	0.217	0.263
alfg(m)	0.727	0.769	0.671	0.719	0.794	0.721	0.801	0.679	0.632	0.738	0.784	0.718
betg(m)	15.82	15.54	18.42	16.13	11.61	11.79	12.22	12.75	18.59	13.18	14.53	18.62
ri(m)	15.7	13.0	20.1	30.2	33.3	33.8	52.1	28.2	29.5	13.7	14.0	14.5
tamx(m)	10.9	12.6	16.8	22.1	26.6	30.9	32.0	31.5	29.2	23.3	16.0	11.2
tamn(m)	-0.2	0.7	3.9	8.6	13.1	17.8	19.4	18.8	15.7	8.7	3.0	-0.1
ra(m)	166.	244.	336.	455.	523.	556.	531.	483.	421.	323.	218.	168.

TENNESSEE - KNOXVILLE alat(deg)= 35.82 yrs= 87. elev (m)= 289.6 tp05(mm)= 62.5 tp6(mm)= 125.7

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.506	0.531	0.506	0.528	0.473	0.444	0.494	0.422	0.477	0.503	0.467	0.466
prw1(m)	0.317	0.329	0.327	0.294	0.253	0.291	0.304	0.257	0.191	0.170	0.271	0.289
alfg(m)	0.747	0.774	0.737	0.759	0.916	0.720	0.778	0.681	0.732	0.729	0.731	0.664
betg(m)	12.42	13.13	13.97	11.23	8.53	13.41	11.48	12.52	12.14	11.15	12.45	16.36
ri(m)	7.1	10.7	15.7	24.1	31.2	28.4	32.0	19.8	18.3	13.2	12.7	15.7
tamx(m)	9.9	11.4	15.8	21.6	26.1	30.6	31.7	31.0	28.6	22.5	15.1	10.2
tamn(m)	-0.5	0.2	3.5	8.4	13.2	18.1	19.8	18.9	15.9	8.9	3.1	-0.2
ra(m)	161.	239.	331.	450.	518.	551.	526.	478.	416.	318.	213.	163.

TENNESSEE - MEMPHIS alat(deg)= 35.05 yrs= 86. elev (m)= 80.2 tp05(mm)= 67.3 tp6(mm)= 146.1

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.472	0.455	0.491	0.431	0.482	0.469	0.395	0.397	0.424	0.324	0.374	0.439
prw1(m)	0.246	0.294	0.270	0.295	0.184	0.200	0.241	0.205	0.154	0.146	0.222	0.259
alfg(m)	0.645	0.753	0.755	0.729	0.717	0.755	0.698	0.620	0.658	0.657	0.715	0.686
betg(m)	18.11	15.72	15.37	19.91	20.47	13.59	16.56	19.38	19.74	15.11	15.34	17.37
ri(m)	17.0	18.0	30.2	30.5	38.1	29.5	54.6	41.4	27.9	16.3	35.3	32.8
tamx(m)	10.2	11.8	16.7	22.2	26.9	31.3	32.8	32.6	29.6	24.2	16.3	11.4
tamn(m)	0.5	2.1	5.6	10.8	15.4	20.1	21.8	21.0	17.3	10.8	4.3	1.1
ra(m)	157.	236.	330.	440.	511.	559.	538.	481.	411.	316.	216.	158.

TENNESEE - NASHVILLE alat(deg)= 36.12 yrs= 87. elev (m)= 175.9 tp05(mm)= 61.5 tp6(mm)= 124.5

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.484	0.521	0.500	0.476	0.485	0.516	0.422	0.386	0.462	0.408	0.399	0.493
prw1(m)	0.274	0.299	0.280	0.323	0.248	0.238	0.272	0.214	0.174	0.161	0.249	0.280
alfg(m)	0.655	0.835	0.705	0.763	0.743	0.718	0.705	0.751	0.647	0.738	0.805	0.721
betg(m)	15.65	12.40	16.56	13.00	14.05	13.54	13.31	12.42	17.25	11.58	11.13	14.43
ri(m)	15.7	16.3	21.1	18.8	47.2	24.9	48.3	42.7	27.9	20.3	22.1	16.3
tamx(m)	9.4	10.9	15.6	21.4	26.2	30.9	32.6	31.9	29.2	23.2	15.1	10.1
tamn(m)	-0.6	0.6	4.2	9.3	14.0	18.9	20.7	20.0	16.6	9.9	4.1	0.3
ra(m)	149.	228.	322.	432.	503.	551.	530.	473.	403.	308.	208.	150.

TEXAS - AMARILLO alat(deg)= 35.23 yrs= 28. elev (m)=1098.5 tp05(mm)= 65.8 tp6(mm)= 121.9

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.313	0.353	0.326	0.376	0.443	0.448	0.464	0.373	0.303	0.477	0.419	0.365
prw1(m)	0.081	0.117	0.121	0.107	0.212	0.207	0.203	0.203	0.147	0.090	0.061	0.092
alfg(m)	0.654	0.748	0.748	0.687	0.575	0.582	0.615	0.639	0.572	0.664	0.834	0.645
betg(m)	5.44	4.39	6.10	8.94	14.22	19.13	13.87	14.22	14.33	12.17	5.44	6.02
ri(m)	3.3	2.3	9.7	8.9	39.9	52.8	40.6	37.6	25.4	13.2	2.3	38.1
tamx(m)	9.9	12.7	16.9	22.2	26.7	32.8	34.6	33.9	29.7	23.7	15.6	11.2
tamn(m)	-4.7	-2.4	0.4	6.1	11.6	17.2	19.4	18.9	14.6	7.9	-0.1	-3.2
ra(m)	275.	362.	450.	550.	604.	675.	666.	558.	532.	372.	322.	268.

TEXAS - AUSTIN alat(deg)= 30.30 yrs= 27. elev (m)= 182.0 tp05(mm)= 86.4 tp6(mm)= 182.9

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.444	0.479	0.393	0.397	0.418	0.478	0.312	0.430	0.445	0.390	0.438	0.479
prw1(m)	0.174	0.205	0.179	0.190	0.197	0.117	0.101	0.115	0.172	0.143	0.146	0.144
alfg(m)	0.601	0.555	0.632	0.613	0.571	0.611	0.547	0.643	0.637	0.550	0.593	0.556
betg(m)	9.30	16.36	9.35	17.48	21.36	25.22	17.81	16.59	20.45	26.62	13.56	14.07
ri(m)	20.6	32.3	13.7	26.4	55.4	36.3	46.5	28.4	31.8	39.9	18.3	11.4
tamx(m)	15.7	17.8	21.4	25.6	29.6	33.3	35.1	35.3	32.1	27.7	20.9	17.1
tamn(m)	4.7	6.4	9.3	14.1	18.3	22.1	23.3	23.2	20.3	15.3	8.8	5.9
ra(m)	279.	347.	417.	445.	541.	612.	639.	585.	493.	398.	295.	256.

TEXAS - BROWNSVILLE alat(deg)= 25.90 yrs= 29. elev (m)= 4.6 tp05(mm)= 95.3 tp6(mm)= 205.7

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.459	0.485	0.413	0.380	0.433	0.527	0.387	0.484	0.540	0.420	0.440	0.492
prw1(m)	0.148	0.158	0.097	0.087	0.094	0.107	0.093	0.138	0.226	0.160	0.138	0.134
alfg(m)	0.614	0.469	0.646	0.517	0.535	0.586	0.615	0.628	0.579	0.507	0.623	0.559
betg(m)	8.23	13.44	5.21	16.15	24.84	17.73	9.70	15.27	22.96	27.28	9.70	7.90
ri(m)	8.4	18.5	2.8	41.4	25.4	35.8	25.7	45.0	31.0	58.9	21.1	21.1
tamx(m)	21.4	22.9	24.9	27.9	30.6	32.6	33.6	33.8	32.1	29.5	25.0	22.3
tamn(m)	11.2	12.6	15.0	18.6	21.6	23.7	24.2	24.1	22.6	19.2	14.6	11.9
ra(m)	297.	341.	402.	456.	564.	610.	627.	568.	475.	411.	296.	263.

TEXAS - CORPUS CHRISTI alat(deg)= 27.77 yrs= 30. elev (m)= 12.5 tp05(mm)= 95.3 tp6(mm)= 201.9

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.456	0.482	0.327	0.309	0.408	0.422	0.371	0.448	0.529	0.438	0.438	0.431
prw1(m)	0.171	0.165	0.138	0.130	0.153	0.130	0.104	0.113	0.219	0.142	0.136	0.141
alfg(m)	0.483	0.547	0.635	0.453	0.581	0.560	0.562	0.597	0.565	0.553	0.636	0.544
betg(m)	11.05	12.29	6.05	22.40	19.68	24.41	14.86	25.17	26.14	21.89	10.64	11.66
ri(m)	11.9	3.3	25.9	24.9	33.3	52.1	26.7	23.6	54.1	27.2	18.0	7.1
tamx(m)	19.7	21.0	23.6	26.9	29.9	32.5	34.2	34.3	32.3	29.2	23.2	20.4
tamn(m)	8.6	10.5	13.3	17.2	20.6	23.3	23.7	23.6	21.9	18.1	12.4	9.7
ra(m)	275.	342.	424.	454.	574.	628.	600.	572.	468.	406.	278.	272.

TEXAS - DALLAS alat(deg)= 32.85 yrs= 28. elev (m)= 146.6 tp05(mm)= 85.1 tp6(mm)= 177.8

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.431	0.456	0.404	0.471	0.447	0.392	0.348	0.298	0.440	0.320	0.447	0.435
prw1(m)	0.153	0.195	0.203	0.196	0.202	0.146	0.105	0.139	0.143	0.126	0.134	0.131
alfg(m)	0.750	0.653	0.612	0.673	0.632	0.713	0.568	0.581	0.667	0.525	0.652	0.661
betg(m)	9.09	11.38	14.88	23.47	20.93	16.74	17.86	16.64	22.40	32.54	17.88	14.96
ri(m)	14.2	8.1	10.2	29.0	34.8	38.9	44.2	57.1	32.5	25.9	22.9	6.9
tamx(m)	13.2	15.3	19.4	24.1	28.2	32.7	34.7	35.0	31.3	26.0	18.7	14.4
tamn(m)	2.2	4.1	7.3	12.6	17.3	22.1	24.1	23.9	19.7	13.8	6.7	3.4
ra(m)	250.	320.	427.	488.	562.	651.	613.	593.	503.	403.	306.	245.

TEXAS - EL PASO alat(deg)= 31.80 yrs= 29. elev (m)= 974.8 tp05(mm)= 40.6 tp6(mm)= 76.2

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.368	0.352	0.288	0.235	0.257	0.250	0.320	0.441	0.376	0.328	0.320	0.368
prw1(m)	0.060	0.067	0.075	0.046	0.043	0.087	0.229	0.168	0.093	0.077	0.064	0.080
alfg(m)	1.011	0.911	0.817	0.658	0.709	0.694	0.645	0.716	0.558	0.827	0.890	0.976
betg(m)	2.69	4.55	4.19	4.78	5.28	7.09	8.59	5.64	12.95	5.44	3.71	2.97
ri(m)	17.8	4.6	22.9	3.6	10.2	15.0	21.3	16.8	21.8	11.4	1.5	3.3
tamx(m)	13.5	16.9	20.8	25.7	30.5	35.2	34.9	33.9	30.8	26.0	19.1	14.2
tamn(m)	-1.4	2.1	4.6	9.2	13.8	19.2	20.5	19.8	16.3	10.0	2.3	-0.7
ra(m)	333.	430.	547.	654.	714.	729.	666.	640.	576.	460.	372.	313.

TEXAS - GALVESTON alat(deg)= 29.30 yrs= 98. elev (m)= 2.1 tp05(mm)= 96.5 tp6(mm)= 228.6

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.383	0.436	0.341	0.311	0.407	0.468	0.453	0.462	0.574	0.424	0.425	0.436
prw1(m)	0.232	0.251	0.186	0.172	0.141	0.141	0.162	0.206	0.175	0.131	0.156	0.221
alfg(m)	0.640	0.622	0.567	0.551	0.589	0.580	0.609	0.635	0.523	0.727	0.613	0.691
betg(m)	12.93	14.38	13.03	20.47	21.29	26.14	21.67	20.45	34.47	15.98	18.24	16.54
ri(m)	25.9	12.7	34.8	33.8	61.2	24.4	34.8	51.3	30.5	49.5	39.4	33.5
tamx(m)	15.8	16.9	19.2	22.8	26.7	29.8	30.7	30.8	29.2	25.8	20.3	17.1
tamn(m)	9.6	10.7	13.4	17.8	21.9	25.4	26.1	26.1	24.2	20.2	14.1	10.9
ra(m)	297.	341.	402.	456.	564.	610.	627.	568.	475.	411.	296.	263.

TEXAS - HOUSTON alat(deg)= 29.97 yrs= 36. elev (m)= 15.2 tp05(mm)= 95.3 tp6(mm)= 223.5

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.407	0.492	0.369	0.410	0.440	0.478	0.443	0.464	0.541	0.508	0.410	0.473
prw1(m)	0.253	0.237	0.218	0.212	0.189	0.156	0.214	0.219	0.186	0.135	0.205	0.232
alfg(m)	0.558	0.564	0.507	0.485	0.565	0.585	0.594	0.581	0.645	0.545	0.584	0.626
betg(m)	15.62	19.15	14.58	22.83	27.56	28.24	18.03	18.97	21.41	26.26	19.66	16.84
ri(m)	17.3	24.4	19.3	61.2	60.2	53.8	36.8	55.9	40.9	42.4	26.2	23.1
tamx(m)	17.6	18.6	22.1	25.6	29.8	32.8	33.4	33.8	31.7	27.9	21.7	18.6
tamn(m)	6.4	7.8	10.4	15.0	19.0	22.2	23.2	23.1	20.7	15.8	10.3	7.7
ra(m)	297.	341.	402.	456.	564.	610.	627.	568.	475.	411.	296.	263.

TEXAS - SAN ANTONIO alat(deg)= 29.53 yrs= 26. elev (m)= 240.2 tp05(mm)= 85.6 tp6(mm)= 179.1

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.446	0.494	0.409	0.387	0.403	0.417	0.319	0.378	0.486	0.445	0.448	0.432
prw1(m)	0.180	0.195	0.166	0.179	0.195	0.123	0.088	0.115	0.167	0.135	0.140	0.158
alfg(m)	0.521	0.604	0.502	0.545	0.592	0.562	0.495	0.566	0.689	0.600	0.577	0.606
betg(m)	9.96	11.51	10.67	14.83	18.26	24.05	21.36	19.53	16.51	19.35	15.06	8.71
ri(m)	7.4	19.8	12.7	51.6	43.9	38.9	29.0	32.0	43.2	35.8	35.1	11.2
tamx(m)	16.8	18.9	22.4	26.0	29.6	33.1	34.4	34.6	31.4	27.5	21.3	18.6
tamn(m)	5.3	7.1	9.8	14.2	18.6	22.3	23.3	23.0	20.4	15.3	9.2	5.6
ra(m)	279.	347.	417.	445.	541.	612.	639.	585.	493.	398.	295.	256.

TEXAS - WACO alat(deg)= 31.62 yrs= 26. elev (m)= 152.7 tp05(mm)= 85.1 tp6(mm)= 181.6

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.397	0.424	0.417	0.414	0.429	0.416	0.344	0.386	0.455	0.337	0.425	0.414
prw1(m)	0.148	0.210	0.166	0.203	0.188	0.138	0.072	0.111	0.138	0.123	0.142	0.133
alfg(m)	0.650	0.744	0.676	0.573	0.612	0.651	0.639	0.711	0.706	0.626	0.707	0.677
betg(m)	10.54	9.83	11.33	21.29	25.76	17.75	12.52	13.87	19.71	21.79	14.73	11.94
ri(m)	10.7	17.0	17.5	23.9	40.1	22.9	50.8	29.2	31.8	36.8	8.9	12.2
tamx(m)	14.6	16.6	20.6	25.2	29.3	33.6	35.6	35.9	32.3	27.3	20.1	16.0
tamn(m)	3.2	5.0	8.2	13.2	17.7	21.9	23.7	23.5	19.9	14.2	7.4	4.3
ra(m)	250.	320.	427.	488.	562.	651.	613.	593.	503.	403.	306.	245.

UTAH - MILFORD alat(deg)= 38.43 yrs= 9. elev (m)=1532.5 tp05(mm)= 26.2 tp6(mm)= 50.8

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.364	0.400	0.497	0.442	0.412	0.403	0.344	0.392	0.313	0.408	0.364	0.441
prw1(m)	0.151	0.200	0.156	0.153	0.099	0.079	0.119	0.147	0.100	0.078	0.111	0.131
alfg(m)	0.863	0.990	0.981	0.920	0.998	0.770	0.771	0.890	0.721	0.848	0.889	0.956
betg(m)	3.10	2.67	3.38	4.04	3.38	4.70	3.91	2.84	6.78	4.44	4.29	2.84
ri(m)	3.3	3.6	3.6	4.1	7.4	4.6	9.7	10.7	5.6	5.1	4.3	2.3
tamx(m)	2.2	6.0	11.9	17.6	23.2	28.8	33.6	31.9	27.1	19.6	11.7	4.8
tamn(m)	-11.4	-7.3	-3.9	-0.1	4.3	8.7	13.1	12.2	6.9	0.4	-5.8	-9.3
ra(m)	236.	339.	468.	563.	625.	712.	647.	618.	518.	394.	289.	218.

UTAH - SALT LAKE CITY alat(deg)= 40.78 yrs= 29. elev (m)=1286.3 tp05(mm)= 21.6 tp6(mm)= 57.1

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.479	0.397	0.463	0.525	0.487	0.500	0.315	0.373	0.389	0.461	0.434	0.497
prw1(m)	0.226	0.263	0.236	0.239	0.165	0.139	0.104	0.139	0.111	0.108	0.170	0.230
alfg(m)	0.854	0.881	0.911	0.799	0.853	0.734	0.635	0.638	0.696	0.702	0.821	0.879
betg(m)	4.19	4.29	4.52	7.01	5.23	6.32	7.59	6.71	5.56	6.73	5.38	4.32
ri(m)	4.3	3.8	5.6	6.6	4.8	4.8	7.9	12.2	15.7	6.1	3.8	2.8
tamx(m)	2.2	5.9	11.1	17.1	22.7	28.0	33.5	32.1	26.3	19.2	10.1	4.5
tamn(m)	-8.3	-4.3	-1.0	3.0	7.1	11.0	16.0	15.1	9.4	4.0	-1.9	-5.1
ra(m)	163.	256.	354.	479.	570.	621.	620.	551.	446.	316.	204.	146.

VIRGINIA - NORFOLK alat(deg)= 36.90 yrs= 22. elev (m)= 6.7 tp05(mm)= 82.5 tp6(mm)= 162.6

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.477	0.470	0.429	0.442	0.445	0.435	0.535	0.484	0.478	0.453	0.412	0.405
prw1(m)	0.246	0.289	0.316	0.301	0.242	0.228	0.266	0.272	0.184	0.174	0.223	0.226
alfg(m)	0.728	0.757	0.744	0.782	0.727	0.645	0.704	0.608	0.519	0.619	0.666	0.823
betg(m)	12.52	11.33	10.82	8.41	12.12	15.67	16.43	23.72	26.52	18.11	12.90	11.48
ri(m)	14.5	18.0	11.7	18.8	38.9	25.1	50.5	21.1	31.0	13.7	23.1	8.6
tamx(m)	10.1	10.6	14.0	20.0	25.2	29.4	31.1	30.1	27.2	21.6	16.1	11.0
tamn(m)	0.1	0.1	3.7	8.8	14.3	19.1	20.9	20.4	17.9	11.7	5.4	0.6
ra(m)	192.	294.	358.	434.	528.	545.	530.	450.	395.	301.	222.	188.

VIRGINIA - RICHMOND alat(deg)= 37.50 yrs= 33. elev (m)= 50.0 tp05(mm)= 75.7 tp6(mm)= 148.6

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.474	0.446	0.460	0.477	0.490	0.472	0.448	0.472	0.424	0.382	0.396	0.402
prw1(m)	0.252	0.266	0.284	0.253	0.243	0.226	0.271	0.249	0.187	0.172	0.237	0.215
alfg(m)	0.770	0.843	0.816	0.825	0.734	0.646	0.642	0.607	0.642	0.623	0.620	0.751
betg(m)	9.50	10.95	9.98	8.97	10.64	16.28	20.37	22.38	16.79	18.87	16.31	14.05
ri(m)	15.0	10.7	13.2	13.2	24.1	34.0	41.7	31.0	18.8	16.5	11.4	9.1
tamx(m)	9.1	10.3	15.1	21.3	26.3	30.4	31.9	30.3	27.7	21.4	15.5	9.9
tamn(m)	-1.7	-1.6	2.4	7.7	12.6	17.4	19.3	18.6	14.8	8.2	2.8	-1.4
ra(m)	260.	289.	350.	468.	534.	578.	531.	468.	388.	300.	228.	189.

WASHINGTON - OLYMPIA alat(deg)= 46.97 yrs= 23. elev (m)= 57.9 tp05(mm)= 26.7 tp6(mm)= 104.1

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.816	0.766	0.758	0.698	0.586	0.542	0.489	0.571	0.601	0.707	0.787	0.788
prw1(m)	0.452	0.344	0.321	0.276	0.185	0.194	0.079	0.106	0.160	0.267	0.349	0.455
alfg(m)	0.848	0.862	0.998	0.917	0.998	0.796	0.998	0.753	0.848	0.863	0.800	0.851
betg(m)	12.24	9.96	6.71	5.99	4.34	4.93	3.78	6.65	7.34	10.64	13.46	11.73
ri(m)	4.6	5.3	3.6	6.1	12.7	14.2	9.7	10.4	8.6	7.6	9.1	7.1
tamx(m)	7.3	9.8	12.4	16.8	20.3	22.6	26.5	26.1	22.6	16.8	11.3	8.6
tamn(m)	-0.5	0.1	1.1	3.1	5.3	7.5	8.9	8.8	6.9	4.7	1.8	1.1
ra(m)	85.	167.	257.	432.	509.	487.	486.	436.	321.	205.	122.	77.

WASHINGTON - SPOKANE alat(deg)= 47.63 yrs= 17. elev (m)= 718.4 tp05(mm)= 19.0 tp6(mm)= 48.3

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.648	0.600	0.542	0.409	0.469	0.400	0.240	0.388	0.395	0.479	0.584	0.621
prw1(m)	0.361	0.269	0.239	0.225	0.202	0.200	0.099	0.121	0.154	0.184	0.278	0.386
alfg(m)	0.955	0.998	0.956	0.933	0.889	0.702	0.878	0.746	0.824	0.910	0.903	0.887
betg(m)	4.60	3.63	3.53	3.43	4.09	6.15	3.33	4.39	3.43	4.27	5.05	4.52
ri(m)	2.0	3.3	2.3	2.5	12.2	8.4	13.0	6.3	11.9	4.6	2.8	3.3
tamx(m)	-0.3	3.0	8.3	14.8	20.7	23.6	29.8	28.3	23.7	15.6	6.1	2.2
tamn(m)	-7.1	-5.3	-1.6	2.2	6.2	9.6	13.0	11.6	8.3	3.3	-1.9	-4.3
ra(m)	119.	204.	321.	474.	563.	596.	665.	556.	404.	225.	131.	75.

WASHINGTON - STAMPEDE PASS alat(deg)= 47.28 yrs= 21. elev (m)=1206.4 tp05(mm)= 21.6 tp6(mm)= 101.6

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.867	0.822	0.807	0.774	0.684	0.714	0.530	0.649	0.638	0.723	0.807	0.858
prw1(m)	0.457	0.418	0.388	0.379	0.323	0.284	0.161	0.209	0.251	0.330	0.361	0.442
alfg(m)	0.858	0.772	0.889	0.809	0.846	0.785	0.822	0.775	0.701	0.874	0.824	0.797
betg(m)	17.73	17.27	12.34	11.63	7.24	7.80	5.51	7.16	13.79	15.14	19.38	19.68
ri(m)	5.8	5.1	5.3	4.3	4.1	4.6	9.4	17.3	8.1	5.8	6.9	10.2
tamx(m)	-2.5	-0.5	1.6	5.9	10.6	13.7	18.6	18.1	15.4	8.9	2.1	-0.6
tamn(m)	-6.9	-5.5	-3.8	-0.9	2.6	5.0	8.3	8.2	6.7	2.6	-2.7	-5.0
ra(m)	75.	139.	265.	403.	503.	511.	566.	452.	324.	188.	104.	64.

WASHINGTON - WALLA WALLA alat(deg)= 46.03 yrs= 50. elev (m)= 289.3 tp05(mm)= 25.1 tp6(mm)= 63.5

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.592	0.560	0.486	0.457	0.451	0.336	0.306	0.328	0.415	0.454	0.539	0.548
prw1(m)	0.377	0.262	0.259	0.240	0.197	0.181	0.054	0.085	0.119	0.200	0.304	0.370
alfg(m)	0.878	0.880	0.897	0.878	0.766	0.780	0.671	0.778	0.860	0.702	0.855	0.822
betg(m)	4.42	3.71	3.76	4.24	5.82	5.00	5.28	5.11	4.98	5.97	4.57	4.42
ri(m)	5.8	3.0	3.6	3.6	3.6	3.0	6.1	8.6	2.5	3.0	2.5	4.3
tamx(m)	3.9	7.2	12.4	17.7	22.2	25.9	31.8	30.3	25.5	18.1	9.3	6.6
tamn(m)	-2.6	-0.1	3.1	6.5	9.9	13.1	17.1	16.1	12.3	7.6	2.1	-0.2
ra(m)	121.	205.	304.	462.	558.	653.	699.	562.	410.	245.	146.	96.

WEST VIRGINIA - CHARLESTON alat(deg)= 38.37 yrs= 73. elev (m)= 289.6 tp05(mm)= 59.7 tp6(mm)= 106.7

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.541	0.551	0.577	0.548	0.550	0.500	0.466	0.473	0.473	0.464	0.514	0.521
prw1(m)	0.383	0.395	0.397	0.395	0.314	0.264	0.369	0.249	0.213	0.222	0.279	0.384
alfg(m)	0.741	0.730	0.761	0.828	0.747	0.827	0.680	0.683	0.780	0.693	0.850	0.746
betg(m)	8.00	8.74	9.25	7.72	9.27	8.92	15.19	13.89	10.11	9.65	7.34	7.62
ri(m)	6.6	6.6	17.0	13.2	19.3	30.5	40.6	50.5	18.8	15.2	10.2	6.3
tamx(m)	7.9	9.3	13.7	20.1	25.0	29.2	30.7	29.7	27.4	21.4	13.7	8.6
tamn(m)	-3.1	-2.4	0.6	5.4	10.2	15.3	17.5	16.5	13.2	6.8	1.7	-1.9
ra(m)	174.	254.	349.	472.	573.	620.	609.	553.	488.	300.	202.	164.

WISCONSIN - GREEN BAY alat(deg)= 44.48 yrs= 8. elev (m)= 210.0 tp05(mm)= 50.5 tp6(mm)= 96.5

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.400	0.393	0.495	0.493	0.471	0.487	0.398	0.405	0.426	0.467	0.425	0.420
prw1(m)	0.282	0.217	0.262	0.271	0.339	0.298	0.273	0.267	0.293	0.196	0.223	0.286
alfg(m)	0.821	0.822	0.808	0.781	0.718	0.734	0.688	0.787	0.728	0.724	0.754	0.825
betg(m)	3.30	4.04	4.57	8.79	9.19	10.34	12.93	8.69	11.53	9.27	6.40	3.81
ri(m)	5.3	3.8	4.6	9.4	10.7	16.5	16.3	27.2	24.9	13.5	7.4	2.5
tamx(m)	-4.2	-3.3	2.6	10.9	18.4	24.0	27.3	25.8	21.1	14.2	4.8	-2.7
tamn(m)	-13.5	-13.0	-6.6	-0.1	6.4	12.3	14.8	13.9	10.2	4.1	-3.1	-10.6
ra(m)	143.	215.	308.	389.	461.	509.	526.	447.	343.	236.	140.	110.

WISCONSIN - LA CROSSE alat(deg)= 43.87 yrs= 7. elev (m)= 198.7 tp05(mm)= 59.7 tp6(mm)= 111.8

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.320	0.410	0.425	0.406	0.515	0.448	0.359	0.412	0.465	0.403	0.414	0.413
prw1(m)	0.233	0.161	0.272	0.274	0.296	0.308	0.287	0.245	0.242	0.204	0.178	0.221
alfg(m)	0.838	0.778	0.723	0.791	0.862	0.728	0.732	0.816	0.722	0.793	0.662	0.874
betg(m)	3.23	4.01	6.71	9.19	9.04	14.07	14.10	11.10	13.11	8.76	7.87	3.33
ri(m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tamx(m)	-3.9	-1.9	4.8	13.8	21.0	26.1	29.5	27.8	22.7	16.3	5.8	-1.8
tamn(m)	-14.3	-12.3	-5.3	2.4	8.9	14.5	17.1	15.9	10.9	4.6	-3.3	-10.9
ra(m)	148.	220.	313.	394.	466.	514.	531.	452.	348.	241.	145.	115.

WISCONSIN - MADISON alat(deg)= 43.13 yrs= 18. elev (m)= 261.2 tp05(mm)= 58.4 tp6(mm)= 106.7

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.392	0.409	0.468	0.487	0.522	0.452	0.380	0.369	0.432	0.471	0.419	0.455
prw1(m)	0.284	0.204	0.292	0.322	0.287	0.297	0.282	0.256	0.245	0.204	0.219	0.218
alfg(m)	0.794	0.751	0.783	0.709	0.713	0.695	0.655	0.689	0.631	0.688	0.654	0.767
betg(m)	3.48	4.32	5.59	8.89	10.36	14.43	15.65	13.82	13.94	10.49	8.36	5.44
ri(m)	2.3	4.3	12.7	16.3	30.5	29.0	45.2	30.2	17.5	7.9	6.1	4.3
tamx(m)	-2.3	-0.6	5.4	13.6	20.7	26.2	29.8	28.4	23.1	16.3	6.5	-0.6
tamn(m)	-12.1	-10.7	-4.9	1.6	7.6	13.2	15.7	14.6	10.3	4.2	-2.8	-9.4
ra(m)	148.	220.	313.	394.	466.	514.	531.	452.	348.	241.	145.	115.

WISCONSIN - MILWAUKEE alat(deg)= 42.95 yrs= 17. elev (m)= 204.8 tp05(mm)= 55.9 tp6(mm)= 102.9

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.481	0.449	0.466	0.504	0.463	0.509	0.398	0.410	0.464	0.475	0.414	0.466
prw1(m)	0.288	0.260	0.299	0.349	0.313	0.285	0.288	0.226	0.240	0.206	0.243	0.269
alfg(m)	0.661	0.756	0.711	0.759	0.800	0.670	0.635	0.650	0.638	0.670	0.692	0.695
betg(m)	5.28	4.24	7.14	8.20	7.54	12.34	14.83	13.33	11.99	9.91	8.20	6.07
ri(m)	4.6	5.3	9.1	18.8	17.3	24.6	24.1	22.4	17.5	10.2	6.9	7.1
tamx(m)	-1.6	-0.1	4.9	11.6	17.7	23.9	27.3	26.2	22.1	15.7	7.1	0.4
tamn(m)	-9.7	-8.6	-3.5	2.1	7.1	12.6	16.3	15.8	11.8	5.8	-1.2	-7.4
ra(m)	148.	220.	313.	394.	466.	514.	531.	452.	348.	241.	145.	115.

WYOMING - CHEYENNE alat(deg)= 41.15 yrs= 22. elev (m)=1868.7 tp05(mm)= 44.5 tp6(mm)= 81.3

month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.360	0.414	0.489	0.527	0.597	0.488	0.425	0.373	0.444	0.386	0.398	0.343
prw1(m)	0.125	0.176	0.225	0.206	0.251	0.282	0.293	0.255	0.159	0.123	0.133	0.131
alfg(m)	0.998	0.924	0.833	0.864	0.749	0.689	0.742	0.737	0.735	0.794	0.942	0.967
betg(m)	1.63	1.80	2.97	4.04	7.19	7.67	5.56	5.64	5.44	4.85	2.31	1.65
ri(m)	1.5	1.3	2.5	4.1	8.6	19.8	20.8	18.5	50.8	1.5	2.0	2.0
tamx(m)	2.8	4.3	6.5	11.9	17.1	23.3	28.1	27.2	22.1	15.4	8.3	4.6
tamn(m)	-10.1	-9.1	-6.7	-1.8	2.9	8.1	12.0	11.4	6.2	0.5	-4.9	-8.3
ra(m)	217.	296.	425.	509.	555.	644.	607.	537.	439.	325.	230.	187.

DISTRICT OF COLUMBIA - WASHINGTON alat(deg)= 38.90 yrs= 87. elev (m)= 4.3 tp05(mm)= 81.3 tp6(mm)= 144.8

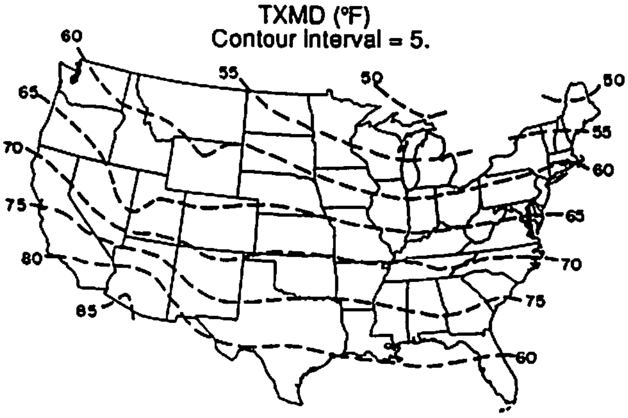
month	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
prw2(m)	0.424	0.415	0.452	0.478	0.455	0.377	0.400	0.441	0.406	0.394	0.361	0.410
prw1(m)	0.265	0.254	0.303	0.276	0.260	0.269	0.243	0.231	0.179	0.162	0.242	0.244
alfg(m)	0.834	0.811	0.828	0.789	0.751	0.622	0.581	0.607	0.635	0.628	0.731	0.679
betg(m)	7.59	9.75	9.83	9.73	10.74	15.34	20.14	20.57	16.38	15.49	12.14	12.90
ri(m)	10.7	8.4	9.1	24.1	44.7	23.9	35.8	36.6	36.6	21.3	8.4	6.6
tamx(m)	6.7	7.6	12.8	18.3	24.2	28.7	30.6	29.4	26.2	20.1	13.6	7.6
tamn(m)	-1.7	-1.5	2.4	6.9	12.7	17.8	20.2	19.2	15.9	9.2	4.1	-0.7
ra(m)	174.	266.	344.	411.	551.	494.	536.	446.	375.	299.	211.	166.

Appendix D. Parameters of Weather Input:

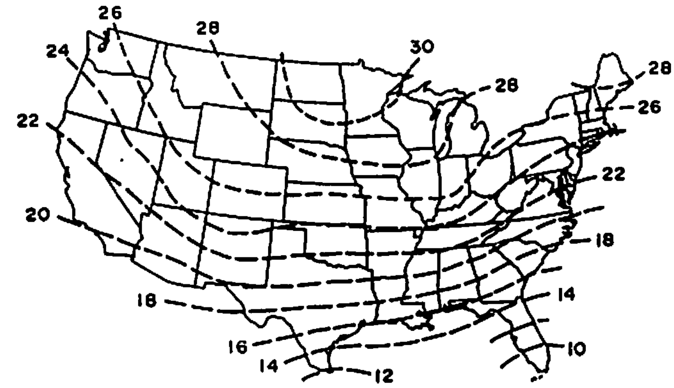
Part 2, Maps of Statistical Parameters for Continental United States

Note: The following maps refer to the weather model parameters that are required by Opus in data lines H02 through H04. The maps show the large scale parameter variations for the continental United States. Actual local values may not always be well predicted by interpolation, especially in rough terrain.

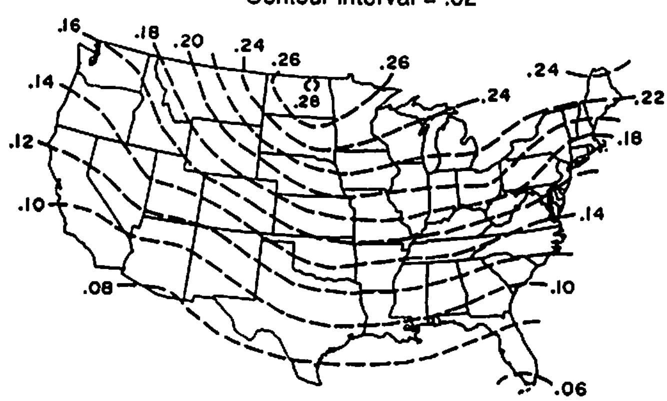
TXMD (°F)
Contour Interval = 5.



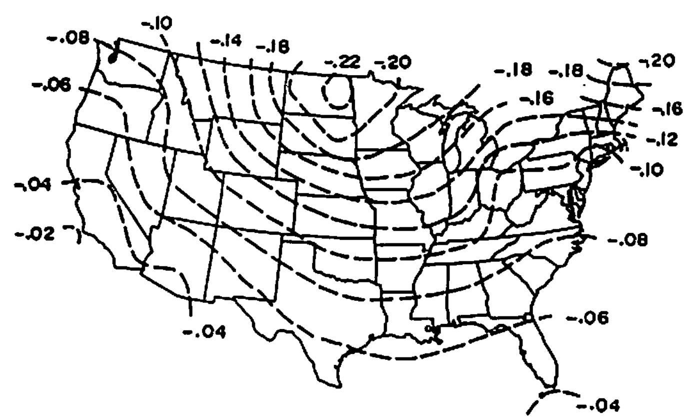
ATX (°F)
Contour interval = 2.



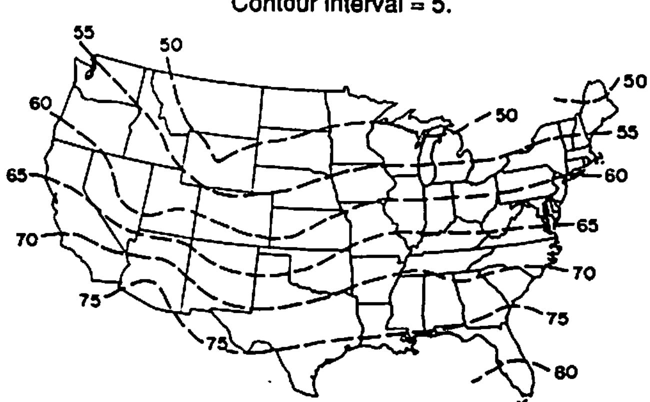
CVTX (°F/°F)
Contour interval = .02



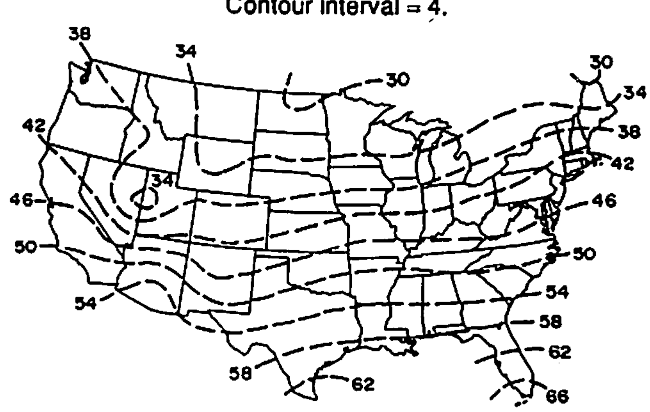
ACVTX (°F/°F)
Contour interval = .02



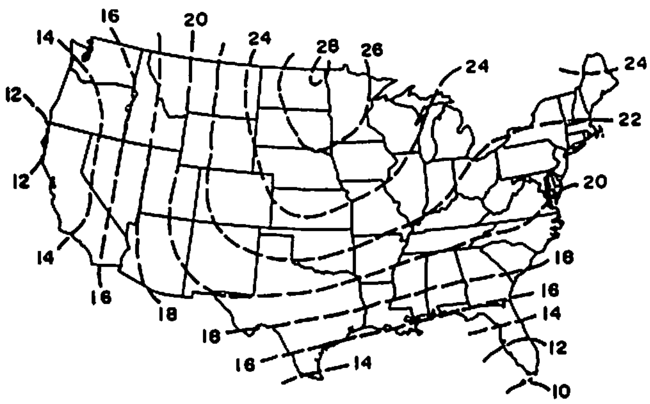
TXMW (°F)
Contour interval = 5.



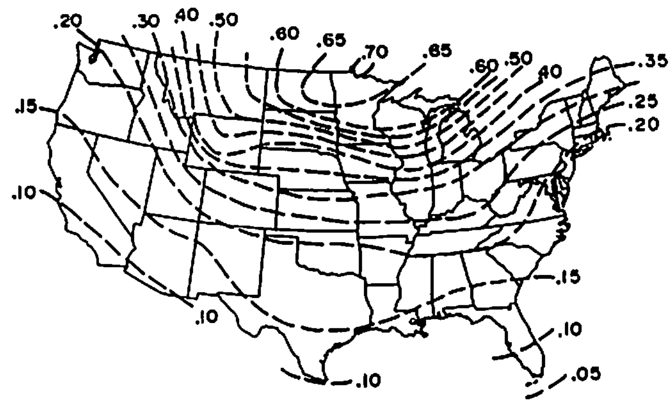
TN (°F)
Contour interval = 4.



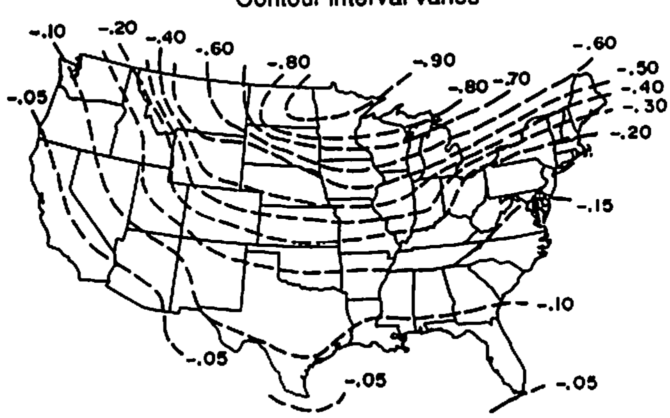
AMTN (°F)
Contour interval = 2.



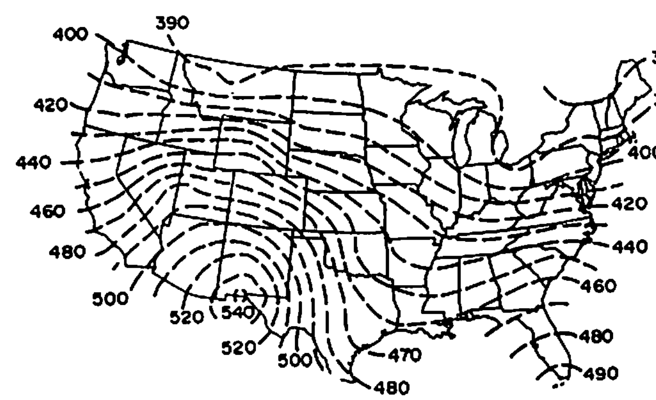
CVTN (°F/°F)
Contour interval = .05



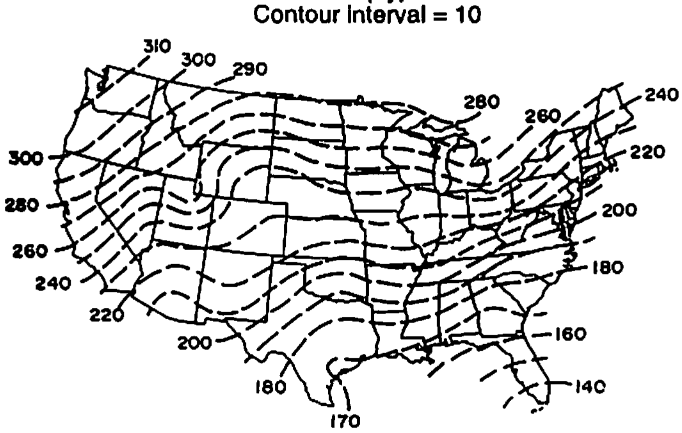
ACVTN (°F/°F)
Contour interval varies



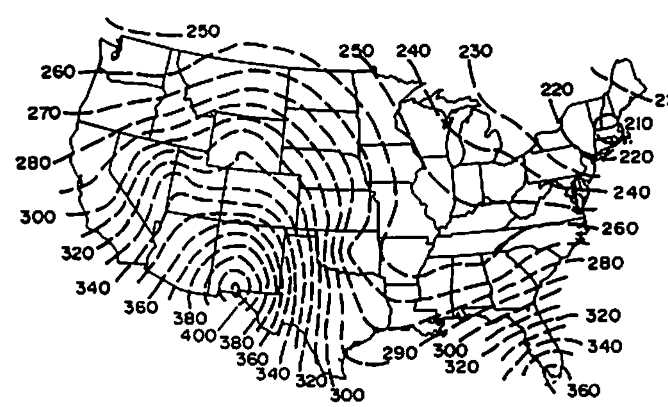
RMD (Ly)
Contour interval varies



AR (Ly)
Contour interval = 10



RMW (Ly)
Contour Interval = 10



Appendix E. Glossary of Input and COMMON Variables for Opus Program

Indexes The following are used in the glossary below as symbolic indexes to indicate the quantity referred to in parentheses following the variable name.

- C - crop
- CL - computational layer
- CP - carbon pool
- D - Julian day
- E - nutrient element
- HL - horizon layer
- I - I^{th} occurrence
- IT - tillage event
- IF - fertilization event
- IP - pesticide application event
- IR - irrigation event
- IT - tillage (mechanical operation) event
- J - particle size class
- K - hydrologic case
- L - hydrologic element
- M - manure type
- MO - month
- N - node, point
- NL - nutrient layer
- P - pesticide
- S - slope location
- ST - storm
- T - tillage operation
- Y - rotation year

NAME	VOL.I NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
A(N)	a		SED	Cross-sectional area of flow at node N [m^2]
A2			HOP1	Runoff peak parameter, IHOP=1
ACTEI	EI	*	ACTDAT	Measured daily erosivity index
ACTMN	T_{min}	*	ACTDAT	Measured daily minimum air temperature [°F or °C]
ACTMX	T_{max}	*	ACTDAT	Measured daily maximum air temperature [°F or °C]
ACTPR	P	*	ACTDAT	Measured daily precipitation [mm or in]
ACTQP	q_p	*	ACTDAT	Measured daily runoff peak discharge [m^3/sec or ft^3/sec]
ACTRAD	R_i	*	ACTDAT	Measured daily solar radiation [langley]
ACTRO		*	ACTDAT	Measured daily runoff volume [mm or in]
ACTSD		*	ACTDAT	Measured daily sediment yield [t/ha or kg/ha]
ACVRD			RMETR	Amplitude of annual cycle of daily value of coefficient of variation of daily radiation for dry days [langley]
ACVRW			RMETR	Amplitude of annual cycle of daily value of coefficient of variation of daily radiation for wet days [langley]
ACVTN		H03	RMETR	Amplitude of annual cycle of coefficient of variation of daily minimum temperature [°F]
ACVTX		H02	RMETR	Amplitude of annual cycle of coefficient of variation of daily maximum temperature [°F]
AES	E_s		STATE	Actual soil evaporation [mm]
AET(C)	E_t		STATE	Actual plant evapotranspiration [mm]

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
AGRAV	g		CONS	Gravitational constant [m/s²]
AGN			RMETR	First-order coefficient in time series expression for seasonal variation of standard deviation of daily minimum temperature
AGX			RMETR	First-order coefficient in time series expression for seasonal variation of standard deviation of daily maximum temperature
AKS	K_s		LOCAL	Current value of net hydraulic conductivity of 10-mm surface layer [mm/min]
AL(N)			SED	Cross-sectional flow area for previous time step at node N [m²]
ALAI(C)	L_p		STATE	Plant leaf area index
ALAM(CL)	λ	C02	SOIL	Pore size distribution index for soil computational layer CL (Brooks and Corey g)
ALBS	ξ	B01	RMETR	Soil surface albedo when smooth [fraction]
ALFG(MO)	α	H07	RMETR	Gamma distribution parameter for statistical description of daily rainfall amount on wet days in month MO
ALIG(M)			MGMT	Lignin content of manure type M [weight fraction]
ALPH(L,N)			AHOP	Hydraulic flow coefficient for hydrologic element L, node N [m/min]
AMIRR		E17	MGMT	Annual depth of irrigation targeted [mm or in]
AMTN		H03	RMETR	Amplitude of annual cycle of daily minimum temperature [F]
ANH(M)		E09	MGMT	Ammonia content in manure type M [%]
ANU(C)			NUTRIN	Actual cumulative nitrogen use by crop [kg/ha]
AOM(M)		E09	MGMT	Total organic matter content in manure type M [%]
APH			RMETR	Wind effect factor in Ritchie's ET equation: APH = 1 + FWIND
APHOS(M)		E09	MGMT	Labile phosphate content in manure type M [%]
APS(K)			AHOP	Plane area per unit channel width [m²], hydrologic case K
APU(C)			NUTRIN	Actual cumulative phosphorus use by crop C of year simulated [kg/ha]
AR		H04	RMETR	Amplitude of sine function annual cycle of daily incoming radiation [langley]
ARRHC(P)	b_{ar}	E06	PESTI	Arrhenius equation activation energy coefficient for pesticide P [Kcal/mole]
ARUP(K,L)	A_u	F07	AHOP	Area contributing at head end of channel [ha or ac]
ASLK	K_u	G04		Average USLE erodibility K for total field area [complex units]
ATN(M)		E09	MGMT	Total nitrogen content in manure type M [%]
ATX		H02	RMETR	Amplitude of sine function annual cycle of daily maximum temperature [°F]
AV	A_p	F11	PONDC	Constant base area of impoundment at 0 depth [m² or ft²]
AWSH			AHOP	Watershed area [m²]
B15(HL)	θ_{15}	C02	SOIL	15-bar soil water content of soil horizon layer HL, used to calculate residual water content, THR [mm/mm or in/in]
BAREA	A			Area of smallest plane unit [m²]
BARENC	n		CONS	Manning's n of bare soil in channels
BARENS	n		CONS	Manning's n of bare soil on surface

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
BC (or PC)			AHOP	Plane flow convergence expressed as tangent of angle between flow lines at extreme edges of plane
BETG(MO)	β	H08	RMETR	Gamma distribution coefficient for statistical description of depth of daily rain on wet days in month MO
BEXTR(P)	f_b	E05	PESTI	Extraction coefficient for pickup of pesticide P by runoff [kg/L]
BGN			RMETR	Coefficient in second-order term for description of annually cyclic time series of daily value of standard deviation of daily minimum temperature [°C]
BGX			RMETR	Coefficient correspondent to BGN but for daily maximum temperature. Derived from input parameters.
BIF			FLOWS	Crust formation parameter
BP(I)			HOP2	Breakpoint accumulated depth of depth-time pair I of current storm [mm]
BULKD			TONCYC	Bulk density of soil in microbially active zone
BV	B_p	F11	PONDC	Coefficient parameter in relation of impoundment depth and area
BWFR			HOP2	Bottom width of furrows, if any [m]
CFNC(C)	$(n_o - n_m)$		NUTRIN	Coefficient of decay with time, for crop C nitrogen content function
CFXN(C)		D04	NUTRIN	Flag constant indicating that crop C is nitrogen fixing: 0 = no 1 = yes
CL(L,J,N)	C_s		SED	Concentration at node N, of particle-size class J, at last time step on element L
CMX(J,N)	C_{smx}		SED	Transportation capacity concentration of particle-size class J, at node N
CNLCH			LABILE	Concentration of soluble nitrate in water leached below roots
CN1	CN		HOP1	SCS Curve Number, nominal for AMC I, hydrology option 1
CN2	CN	B01		SCS Curve Number, nominal for AMC II
CO2			PLOTS	Carbon dioxide source/sink (See also CSRSNK.)
COEFF		H13	RMETR	Evaporation pan coefficient, used if pan data are taken instead of radiation
CONA			BOTH	Maximum daily stage-2 soil evaporation amount [mm]
CONF				Units conversion parameter
CONRN		B01	LABILE	Concentration of nitrogen in rainfall [mg/L or ppm]
CONTHM			SOIL	Surface-soil heat flux diffusivity [mm²/min]
CONTHS(CL)			SOIL	Local soil heat flux diffusivity, soil layer CL [mm²/min]
CONVF(C)	c_e	D03	CROP	Crop C radiation conversion factor [kg/ha/langley]
CONY(C)		D04	CROP	Nitrogen content in crop C yield [kg/kg or lb/lb]
COVI(C)		D03	CROP	Permanent plant cover (0.0 to 1.0) of perennial crop C
CPADS(CL,P)	C_a		PESTI	Concentration of pesticide P in layer CL that is adsorbed onto organic or mineral material
CPQIR(P)			PESTI	Concentration of pesticide P in irrigation

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
CQ		F11	PONDC	Coefficient parameter in relation of impoundment discharge and depth [m^3/min or ft^3/min]
CSRSNK			PLOTS	Carbon source/sink (See also CO2.)
CT(J,N)			SED	Concentration of sediment particles of size class J, at node N, in surface water
CUS	ϕ_p		HOP1	USLE daily crop practice factor may be read in as 1.0 but is updated daily with residue and crop changes
CV	c_p	F11	PONDC	Exponent parameter in relation of impoundment depth and area
CVRD			RMETR	Annual mean coefficient of variation of incoming solar radiation on dry days [langley]
CVRW			RMETR	Annual mean coefficient of variation of incoming solar radiation on wet days [langley]
CVTN		H03	RMETR	Annual mean coefficient of variation of daily minimum temperature [°F]
CVTX		H02	RMETR	Annual mean coefficient of variation of daily maximum temperature [°F]
D50				Mean particle size
DA	A	B01	HOP1	Catchment area [ha or ac]
DAMR(NL,E)			PARAM	Fractions of mineral N and of S absorbed by residue (Note that layer=1 or 2 but never 3)
DAMRMN(E)			PARAM	Minimum C/N and C/P ratios allowed in residue after direct absorption
DASL	f_z	B01	LABILE	Depth of active surface layer (0.0-10.0 mm) [mm or in]
DATNAM(20)		H01		Hollerith name of rainfall data used; 80 characters
DAYL				Length of daylight [min]
DCA	C_a		DRAT	Coefficient in draintile equation
DCB	C_b		DRAT	Coefficient in draintile equation
DDEM(C)		D02	CROP	Celsius degree-days between planting and emergence of crop C [°C-days or °F-days]
DDIMP	z_d	E18	SOIL	Depth from draintiles to limiting or impervious layer [m or ft]
DDM	Δ_{pm}			Potential daily production of plant mass [kg/ha]
DDMX(C)		D02	CROP	Celsius degree-days between emergence and senescence of crop C [°C-days or °F-days]
DDYR			STATE	Mean annual total °C-days for a location based on meteorological data given, and threshold temperature of first listed crop. Calculated by the program, for comparison with crop °C-day senescence parameters.
DEACT(C)		D03	CROP	Measured daily rate of conversion from live to dead standing crop C after maturity [kg/kg/day or lb/lb/day]
DEC1(E)	k_1		PARAM	Structural decomposition rate for element E [yr^{-1}]
DEC2(E)	k_x		PARAM	Metabolic decomposition rate for element E [yr^{-1}]
DEC3	k		PARAM	Decomposition rate of soil organic matter with fast turnover [yr^{-1}]
DEC4	k		PARAM	Decomposition rate of soil organic matter with slow turnover [yr^{-1}]
DEC5	k		PARAM	Decomposition rate of soil organic matter with intermediate turnover [yr^{-1}]

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
DEFAC	$(f_w f_t)$		PLOTS	Decomposition factor combining the effects of temperature and moisture
DELH(L,N)			SED	Net local gain or loss of soil depth due to erosion/sedimentation [m]
DELV			CSTATE	Change in water storage in computational layer over current time step [mm]
DENH2O	γ_w		CONS	Density of water [kg/m^3]
DEPDR			DRAT	Depth to draintiles, if any [mm]
DEPIN(Y,I)		E14	MGMT	Depth of incorporation or injection of Ith manure application in rotation year Y [mm or in]
DEPST(Y,IP)		E16	MGMT	Depth of injection of pesticide in application IP of rotation year Y [mm or in]
DFRW(T)		E03	MGMT	Furrow depth resulting from particular tillage operation T; negative indicates that cultivation leaves surface as is [cm or in]
DFRX(L,N)			AHOP	Current depth [m] of furrows or channel at each location along flow path
DINIT		F07		Initial depth of channel below mean surface [m]
DINT				Measure of daily interception of rain [mm]
DKC(C)	c_d	D04	CROP	Decay constant in relation between plant C maturity and nitrogen content
DKFL(P)		E05	PESTI	Decay constant for time decay of pesticide P on leaf [day^{-1}]
DKOC(P)	K_{oc}	E05	PESTI	Equilibrium constant for adsorbed pesticide P in soil [L/kg]
DKSOIL(P)	K_{ps}	E05	PESTI	Decay constant for time decay of pesticide P in soil [day^{-1}]
DKTEMP(P)		E06	PESTI	Coefficient for temperature effect on decay rate of pesticide P
DKTHE(P)		E06	PESTI	Coefficient for water-content effect on decay rate of pesticide P
DLTA(J)			SEDCH	Relative erodibility for particle-size class J at current conditions
DM(C)	m_p		STATE	Current plant mass (dry matter) of crop C
DMINIT(C)		D03	CROP	Mass of seedling material when crop is started from seedling [kg/ha]
DMULT1			PARAM	Cultivation factor for soil organic matter
DMULTS(NL)			PARAM	Cultivation factors for structural material (first parameter is for litter layer, second is for soil)
DPFR		B02	HOP2	Depth of furrows [m or ft]
DPS(J)	y_d	G02	SED	Effective mean diameter of particle-size class J (read in mm and converted) [mm or in]
DRSP		E18	SOIL	Spacing of drains, if any [m or ft]
DTBS				Time interval between storms [min]
DTDAY				Time interval [days]
DTE				Weighted time of evaporation in interstorm ET period [min]
DTI				Time interval between storm starts or 1 day, whichever is smaller [min]
DTILL		B02		Initial depth to plowpan [cm or in]
DWDR			RMETR	Expected value of depression of daily solar radiation on wet days compared to dry days, [langley]

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
DWDT			RMETR	Expected value of depression of daily maximum temperature on wet days compared to dry days [°C]
DWTB		B01		Depth to mean water table (or to drains if IFDRAN >0) [m or ft]
DZ(CL)			SOIL	Thickness of soil computational layer CL [mm]
DZB(CL)			SOIL	Distance between center of layer CL and CL-1 [mm]
DZL(NL)			NUTRIN	Thickness of nutrient layer NL [mm]
EDEPTH			PARAM	Depth of soil used to compute soil loss [m]
EFTL(T)	e_c	E03	MGMT	Mixing efficiency of tillage operation T
EI			FLOWS	Storm or daily USLE EI factor [mJ-mm/ha-hr]
EK(L)	c_f	G04	SED	Coefficient in critical shear type erosion equation for concentrated flow, L = 2 or 3
EN	b		AHOP	Uniform flow discharge rating exponent (5/3 for Manning's n)
EO	E_o			Total interval potential ET [M]
EPNFA(NL)	c_A		PARAM	Regression intercept that determines effect of annual precipitation on atmospheric nitrogen fixation
EPNFS(NL)	b_A		PARAM	Regression slope that determines effect of annual precipitation and annual potential evapotranspiration on soil nitrogen fixation
EPS(CL)	ε		SOIL	Exponent in relation of soil K to Θ
EQ		F11	PONDC	Exponent in relation of impoundment depth and discharge
EQSD(J)			SED	Equivalent sand diameter of particle-size or aggregate-size class J [m]
ER			FLOWS	Ratio of enrichment of specific surface in waterborne sediment, compared to surface soil
ES1			BOTH	Cumulative stage-1 soil evaporation [mm]
ESL				Test value for stage-1 soil evaporation limit
ESRSNK(E)			PLOTS	Source/sink for N or P
ETA	η			Exponent in relation of soil K and H = 2 + 3[ALAM(J)] (Brooks-Corey)
ETAI			HOP2	1/ETA
FB	I_p		FLOWS	Amount of infiltration before runoff [mm]
FC	K_s		HOP2	Effective surface hydraulic conductivity [mm/min]
FERA(Y,IF)		E14	MGMT	Amount of ammonia in I^{th} fertilization of rotation year Y [kg/ha or lb/ac]
FERN(Y,IF)		E14	MGMT	Amount of nitrogen in I^{th} fertilization of rotation year Y [kg/ha or lb/ac]
FEROD(CL)		C03		Relative erosion resistance of soil layer CL: 0 = erodible 1 = erosion resistant
FERP(Y,IF)		E14	MGMT	Amount of phosphate in I^{th} fertilization of rotation year Y [kg/ha or lb/ac]
FKA	K_c		FLOWS	Minimum surface hydraulic conductivity [mm/min]
FLIM	K_s		AHOP	Minimum profile soil hydraulic conductivity [mm/min]
FRACA(IP)		E16	PESTI	Application loss of pesticide P [fractional]
FRACL(J)		G02	SED	Fraction of clay-sized primary particles in sediment-size class J
FRACP(IP)		E16	PESTI	Fraction of pesticide P that ends up on plant surfaces
FRASL(J)		G02	SED	Fraction of silt-sized primary particles in sediment-size class J

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
FRASN(J)	f_s	G02	SED	Fraction of sand-sized primary particles in sediment-size class J
FRLIGN(NL)			PLOTS	Fraction of structural material in layer NL that is lignin
FRORG(J)		G02	SED	Fraction of organic matter associated with particles in sediment-size class J
FSAND			TONCYC	Fraction of sand in soil
FURCAP			FLOWS	Storage capacity of furrows when level; in such a way that this storage must be filled before runoff occurs [mm]
FWASH(P)		E05	PESTI	Fraction of pesticide P that is soluble in rainwater
FWIND	c_w	B01		Evaporation enhancement factor for wind and humidity effect (mean), default = 0.28
GA	G		HOP2	Effective capillary suction parameter in infiltration relation [mm]
GLAT		B01		Catchment latitude [degrees] POS = Northern Hemisphere NEG = Southern Hemisphere
GX				Ratio of dry matter potential to harvested yield potential
GZ(CL)			SOIL	Depth to bottom of computational soil horizon layer CL [mm or in]
GZC			HOP2	Depth to infiltration control layer [mm]. This soil depth must be saturated before runoff begins. Occurs only with a limiting subsurface soil layer.
GZH(HL)		C02	IO	Depth to bottom of soil horizon layer HL [mm]
GZTL			STATE	Depth to bottom of deepest root penetration [mm]
H(CL)	ψ		SOIL	Capillary potential in soil pores in layer CL [mm]
HDL			RMETR	Trigonometric function relating to day length
HF(L,N)			AHOP	Depth of deposition in channel L at location N, from original channel bottom [mm]
HM	$\bar{h}$		SOIL	Depth of saturated zone built up above drain tiles (if any) [mm]
HOPI				Hollerith name of hydrological option
HOUT			SOIL	Capillary head at lower boundary condition
HPI				Half of PI
IAPLIC(P)		E16	PESTI	Pesticide P application method code: 0 = soil surface application 1 = aerial application; proportions input according to conditions 2 = application with irrigation 3 = aerial application; loss proportion defined by program
IOU			IO	Index for output units
IBDA		A02		Beginning simulation day of month
IBDATE				Beginning date = year*1000 + Julian day
IBMO		A02		Beginning month of simulation
IBROT		A02		Rotation year of simulation start (which set of E11-E17 data describes the starting year)
IBYR		A02	LIMITS	Beginning year of simulation (two digits)
ICHANG			IOC	Output warning message for parameter changes
ICON		A02	IO	Flag switching soil-layerwise output from mass to concentration units for all chemical variables
ICONU			IO	Output concentration units

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
ICR(Y,I)		E02	MGMT	Crop ID for I^{th} crop in rotation year Y
ICRP			STATE	Current crop ID
ICRY			STATE	Current crop rotation year ID. Precedes IRYR for winter planting; otherwise = IRYR.
IDA		E12,E14, E16,E17		Day of operation
IDATE				Date code number for next storm record
IDAYF(Y,IF)			MGMT	Julian date of fertilization
IDAYP(Y,IP)			MGMT	Julian date of pesticide application
IDAYT(Y,IT)			MGMT	Julian date of tillage operation
IDCR(I,C)		D02	CROP	Hollerith name of crop C
IDPL(T)		E03	MGMT	ID number (order of reading in table) of crop, if any, involved in field operation T
IDPST(P)		E05	PESTI	Hollerith name of pesticide P
IDTIL(T)		E03	MGMT	Hollerith name of tillage operation T
IEDA		A02		Day of month of end of simulation
IEDATE			LIMITS	Date code number of end of simulation = year*1000 + Julian day
IEMO		A02		Month of end of simulation
IEYR		A02		Year of end of simulation (two digits)
IFDRAN		A04	NOPTS	Flag for draintile simulation: 0 = no 1 = yes
IFFIX		F01,F07		Flag code for fixed management zone in flow path: 0 = no fixed zone 1+ = existence of an area such as a grass buffer strip along the flow path, and a data card describing this area is read
IFGEN		A04	RMETR	Switch invoking generation of daily rainfall data, used only if IHOP=1 (curve number hydrology option)
IFIRR		A04	MGMT	Flag code for invoking simulation of irrigation: 0 = none 1 = sprinkler 2 = furrow irrigation from local supply 3 = furrow irrigation from ditch supply
IFJUL			ACTDAT	Flag indicating that dates are Julian: 0 = no 1 = yes
IFLHR		A03	HOP2	Flag code for treating hourly breakpoint data: 0 = no 1 = yes
IFNUT		A04	NOPTS	Flag for simulation of nutrient movement and transformations: 0 = no 1 = yes
IFOUT		A03	STATS	Flag for printing of results of each storm simulation: 0 = annual summary 1 = daily storm summary
IFOUTL		F11		Flag for impoundment element outlet control: 0 = none 1 = rating defined as $Q = CQ(ht-ZQ)^{EQ}$ 2 = orifice size given

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
IFPEST		A04	NOPTS	Flag for simulation of pesticide application and rate: 0 = none 1 = pesticides 2 = radionuclides
IFPOND		A04	FLOWS	Flag invoking simulation of farm pond unit: 0 = no 1 = yes, with parameters input for relation of depth to surface area 2 = yes, with pond geometry calculated by Opus from local topography
IFR			MGMT	Nutrient application counter
IFRAN		A03	RMETR	Flag invoking randomization of weather data 0 = daily mean weather used 1 = randomized temperature and radiation
IFREAL		A03		Flag indicating use of actual daily data record of runoff, sediment, air temperatures, or radiation (requires extra input file): 0 = no 1 = yes
IFRNCN		A03	HOP1	Flag indicating that curve number runoff predictions are to be randomized: 0 = no 1 = yes
IFSED		A04	SED	Flag for simulation of sediment transport: 0 = no 1 = yes
IFT		A04		Flag driving program read and use of monthly meteorological data: 0 = no data used 1 = only temperature data used 2 = temperature and radiation data used
IFWRDA		A02		Flag controlling the writing of the date to terminal throughout simulation
IHOP		A03	STATS	Flag to indicate hydrology option: 1 = daily rainfall, curve number runoff 2 = breakpoint rainfall, infiltration methodology
ILBR			SOIL	Index of soil computational layer that is just below the maximum rooting depth. Percolation is defined as the flow from this layer to the layer just below. Water and chemical balance is computed for the region from the soil surface to this layer.
INTSP		A02	IO	Time increment of output to soil layerwise file [days]: 0 = no output 1 = daily output 31 = monthly output (end of each month) 365 = annual output n = output every n days
INUN		A03	STATS	Flag to indicate units of input: 1 = metric 2 = English

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
INUN1			IO	Logical number of read file for meteorological data (default=1)
INUN2			IO	Logical number of read file for parameter data (default=2)
INUN4			IO	Logical number of read file for measured data (default=4)
IOUT3			IO	Logical number of write file for run output
IOU		A03		Flag indication of units of output: 1 = metric 2 = English
IPAN		A03	RMETR	Flag to indicate that pan evaporation data are read instead of daily radiation: 0 = no 1 = yes
IPER(C)		D02	CROP	Flag indicating type of crop C: 0 = annual harvested crop 1 = perennial harvested crop 2 = perennial grazed crop 3 = perennial natural vegetation 4 = annual grazed crop
IPLP			HOP2	Soil computational layer index for top of plowpan, if any
IPRK			SOIL	Number of soil layers through which mass balance is calculated
IPST			PESTI	Code number of next pesticide to be applied
IQUIT			IOC	Output warning message for program stops
IRLEI			ACTDAT	Flag indicating use of actual EI data: 0 = no 1 = yes
IRLPR			ACTDAT	Flag indicating use of actual precipitation data: 0 = no 1 = yes
IRLQP			ACTDAT	Flag indicating use of actual peak runoff data: 0 = no 1 = yes
IRLRAD			ACTDAT	Flag indicating use of actual radiation data: 0 = no 1 = yes
IRLRO			ACTDAT	Flag indicating use of actual runoff data: 0 = no 1 = yes
IRLSD			ACTDAT	Flag indicating use of actual sediment yield data: 0 = no 1 = yes
IRLTM			ACTDAT	Flag indicating use of actual temperature data: 0 = no 1 = yes
IRRDY		E17	MGMT	Number of irrigation days per season
IRU			IOC	Output units
IRYR			STATE	Rotation year (1 TO NYROT)
ISC			CSTATE	Code for indication of flow state of layer: 0 = flowthrough condition 1 = upflow through top layer (no solute outflow) 2 = internal sources or sinks

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
ISC (cont.)				3 = layer 1 flowing out at top and bottom
IST			HOP2	Counter for number of storm segment in breakpoint record containing multiple storms
ISU			IOC	Output sediment units
ITIL			STATE	ID of next tillage operation to be performed
ITOCH		F01		Flag for inclusion of simulation of terrace outlet channel, useful only when NUN is large, and/or a terraced field is described 0 = no 1 = yes
ITRTL			LOCAL	Total number of iterations in surface routing for single event; internal information
ITU			IOC	Output time units
IVARK		A04		Flag for simulation of spatially varying USLE K
IWARN			IOC	Output warning message for parameters
IWARNR			IOC	Output warning message for rainfall
IWU			IOC	Output units
IYR			KEEP	Two-digit current year
JDATE			STATE	Date given as 1000*IYR + Julian date
JDAY			STATE	Julian date
JDE			KEEP	Julian date of end of previous rain
JDPMD			MGMT	Julian date at which a meadow is plowed and converted to an annual crop
JDS			KEEP	Julian date of start of next rain
JDSTR			MGMT	Julian date of start of irrigation season
JINP			LOCAL	Code for existence of upstream inflow: 1 = inflow 0 = no inflow (element L=1)
JLB(L)			LOCAL	Code identifying type of lower boundary of element L, depending on whether the slope is kinematic or less: 0 = kinematic 1 = diffusive wave (critical depth boundary)
JOSHV			MGMT	Julian date at which an oilseed crop is harvested; an oilseed crop is one for which the first four letters of the identifier ICR() are 'SOYB'
JYR				Two-digit year of next breakpoint record
K(4)				Random number generating seeds
KAPPL(Y,IF)		E14	MGMT	Application-method code for fertilization IF in rotation year Y: 0 = surface application 1 = incorporation at some depth DEPIN 2 = with irrigation
KCR				Used locally for ICR(I,Y)
KDATE			ACTDAT	Date code (see JDATE) for date of actual record read under option IFREAL
KL			STATE	Integer code for hydrologic topography condition: 1 = unfurrowed (natural) flow 2 = furrowed flow
KPEST(Y,IP)		E16	MGMT	Pesticide code number for application IP in rotation year Y
KRLRD			ACTDAT	Flag indicating use of actual temperature and/or radiation records. Mandates reading real data file each day of simulation.

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
KTILL(Y,IT)		E12	MGMT	Tillage code for cultivation operation IT in rotation year Y. This number refers then to the number of operation in the menu of different tillage operations read by the user.
LDPH			LIMITS	Season start day offset: 0 = Northern Hemisphere 182 = Southern Hemisphere
LEV			RMETR	Flag for precipitation condition on previous day: 1 = dry 2 = wet
LKL			KEEP	Surface flow state KL from previous day
LLIM			AHOP	Soil layer number at which minimum hydraulic conductivity occurs (see FLIM)
LR			LOCAL	Element number that has surface flow condition that limits hydrology time step, breakpoint option
MANU(I)			MGMT	Manure type used in application I, codes selected in input: 0 = none 1 = beef, solid 2 = dairy, liquid 3 = dairy, solid 4 = horse, solid 5 = domestic sludge 6 = poultry, solid 7 = sheep, solid 8 = swine, liquid 9 = swine, solid 10 = other solid waste, defined by user
MATYP(Y,IF)		E14		Code for type of manure in I^{th} application of rotation year Y
METABC(NL)	M_{rc4}		PLOTS	Metabolic carbon
METABE(NL,E)			PLOTS	Metabolic N or P
METMNR(NL,E)			PLOTS	Amount mineralized due to decomposition of metabolic processes. Negative values indicate immobilization.
MIDN			HOP2	Code used in breakpoint rainfall option indicating record goes into next day
MO		E12,E14,E16,E17	STATE	Month of operation
MO1			STATS	Current month of statistical summation
MOB			LIMITS	Beginning month
MOE			LIMITS	Ending month
MULP(K)	M	F01	AHOP	Number of plane units per intercepting
N		E09		Identifying index of each user-defined manure type
NC		B03		Number of crops on field at start of simulation
NCI(K,L)			AHOP	Index of distance along channel path at which channel flow actually begins for element L, flow state K; corresponds to ARUP(K,L)
NCROP		D01	CROP	Number of different crops in total rotation cycle
NCRPY(Y)			MGMT	Number of crops per year for each rotation year (LE.4)
ND(K,L)			AHOP	Number of computational divisions of element L, surface state K
NDAY			KEEP	Julian day of next storm (option 2)
NDCU				Number of computational nodes for channel
NDEY				Number of days in last simulation year

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
NDPU				Number of computational nodes for the plane
NDYR			STATE	Number of days in current year
NELEM			PARAM	Number of elements (in addition to carbon) that are being modeled 1 = nitrogen flows are simulated 2 = nitrogen and phosphorus flows are simulated
NEPH(K,L)		F07	AHOP	Flag indicating channel type: 0 = ephemeral ≥1 = permanent
NFERT(Y)			MGMT	Number of fertilizer applications in management year Y input into dummy variable NFR
NFIX(K,L,I)			AHOP	Code at each flow point for existence of fixed management conditions (such as grass buffer strip): 0 = unfixed 1 = fixed
NFIXAC			PLOTS	Nitrogen fixation accumulator
NFR(Y)		E13		Number of fertilizer applications in year Y
NHE(K)			AHOP	Number of flow elements in total flow path for flow state K: 1 = field surface only 2 = field plus one channel 3 = terrace outlet channel as well
NIRD		E17	MGMT	Number of days between irrigations in fixed irrigation schedule [days]
NKP		F05		Number of different zones of USLE K along XLP
NL			STATE	Total number of computational soil layers. Water movement is computed to this layer, but water contents in layers near NL are not used in transport or balance calculations.
NLL(NL)			NUTRIN	Index of soil computational layer whose top is at bottom of nutrient layer NL
NLT				Number of computational nodes for soil temperature
NLU(NL)			NUTRIN	Index of soil computational layer whose bottom is at top of nutrient layer NL
NLWT			SOIL	When use of draintiles is simulated, represents index of soil layer to which water table has risen
NMAN		E08		Number of manure types defined by user
NP			HOP2	Number of breakpoint record data points for event record
NPEST(Y)		E15	MGMT	Number of pesticides applied during rotation year Y
NPS		G01	SED	Number of particle-size classes in surface soil
NPST		E04	PESTI	Number of different pesticides considered in simulation
NPT		F02,F08		Number of points along flow element at which slope and slope location are given by user
NSL		C01	IO	Number of different soil horizons specified in root-zone profile
NST			HOP2	Total number of separable storms in breakpoint record
NTI(CL)			SOIL	Index of soil type or horizon in which computational layer CL lies

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
NTILL(Y)			MGMT	Number of tillage operations in a given rotation year Y
NTL		E02	MGMT	Total number of tillage types encountered
NTY(Y)		E11		Number of mechanical operations in rotation year Y
NTYTL(T)		E03	MGMT	Tillage-type code for field operation T: 1 = plant 2 = cultivate 3 = harvest 4 = plow, incorporate standing dry 5 = root harvest or plow, leave standing dry
NUMLAY			NUTRIN	NLL(2)
NUN(K)		F07	AHOP	Number of identical geographical elements in catchment (e.g., 4 parallel terraces)
NUTI(CL)			SOIL	Index of nutrient cycling layer in which computational layer CL lies
NUTL			NUTRIN	Number of nutrient layers
NYROT		E10	MGMT	Number of years in overall rotation sequence [yr]
OCCLUD			PLOTS	Occluded phosphorus
ODTR(L,J,N)	D_f		SED	Detachment rate at node N, element L, particle-size class J, from previous time step
OMN(HL)		C03		Organic matter N in soil horizon HL, ppm
OMP(HL)		C03		Organic matter P in soil horizon HL, ppm
OPC				Weighted effective partial evaporation time from previous day for interval calculation
ORGC(HL)		C03	STATE	Organic carbon in soil horizon HL, changed to fraction of soil by weight [%]
OTS			KEEP	Start time of previous storm
OTSL(CL)			KEEP	Soil temperature from previous calculation
PABRES			PARAM	Amount of residue which will give maximum absorption of N
PAR	A_p	F01		Area [ac or ha] contributing to outlet of first channel or concentrated flow path; this represents the field element area times the value of MULP [ha or ac]
PARENT(E)			PLOTS	Parent material N or P
PAVE(L)			SED	Relative pavement effect on plane surface: 1 = nonerodible
PB(CL)	ψ_b		SOIL	Air entry head of soil [mm]
PBUB(HL)	ψ_b	C02	SOIL	Air entry head of soil horizon HL [mm]; input (absolute value) [in or mm]
PCE				Effective weighted evaporation time during current day
PCF			SEDCH	Coefficient parameter for soil splash from rainfall
PCG	$d_{p:}/g_c$		SEDCH	Parameter for relative rate of erosion during capacity deficit [min^{-1}]
PCH			SEDCH	Parameter for relative effect of runoff water depth in attenuating splash erosion
PCLAY(HL)	f_c	C02	SOIL	Proportion of clay-sized particles in soil horizon HL
PDRYM(C)	ppm	D02	CROP	Potential plant C dry-matter production (optimum) [kg/ha or lb/ac]

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
PEFTXA			PARAM	Intercept parameter for regression equation to compute the effect of soil texture on the microbe-decomposition rate (the effect of texture when no sand is in the soil)
PEFTXB			PARAM	Slope parameter for regression equation to compute the effect of soil texture on the microbe-decomposition rate
PER(J)			HOP1	Potential enrichment ratio for sediment w, all particles larger than size class J deposited
PERPC(P)			IO	Pesticide percolation variable for output
PES	E_s		STATE	Potential interval soil evaporation [mm]
PET	E_p		STATE	Potential interval plant transpiration [mm]
PEV	E_t		KEEP	Potential climatic daily evaporation for current day
PEVCF(MO)			RMETR	Correction factor to convert Fourier stochastic monthly mean values of generated daily potential evapotranspiration energy to be consistent with recorded monthly mean values of solar radiation when available for month MO
PEVMX			RMETR	Maximum theoretical value of daily evapotranspiration [mm]
PFAC			STATS	Conversion factor to produce output print peak flow from interval values of [mm/min] (value depends on option IOUTUN)
PFCOV	F_p		STATE	Relative (0-1) total soil cover by plants
PHRN		B01		pH of rainwater
PI	π			3.14159...
PIN				Amount of rain or snowmelt that infiltrates
PINL				Amount infiltrated from last event
PINRES(NL,P)			PESTI	Amount of pesticide P in soil residue in layer NL
PINSLT		E05		Initial mass of pesticide in top 10 mm of soil [lb/ac or kg/ha]
PKD(CL)	K_d	C03	LABILE	Phosphorus K_d for soil layer CL [mL(H_2O)/g(soil)]
PKNH(CL)			LABILE	K_d for NH_4 in soil layer CL [mL(H_2O)/g(soil)]
PLAI(C)	F_{LM}	D02	CROP	Potential maximum leaf area index of crop C
PLHTA			STATE	Current average plant height [m]
PLIG		D02	CROPS	Plant aboveground lignin content
PLIGST			PARAM	Parameter for effect of lignin on structural decomposition
PLOD			STATE	Maximum depth of plowing; plowpan depth (input) [mm or in]
PLOWD(T)		E03	MGMT	Depth of effect of tillage operation T [mm or in]
PMCO2(NL)			PARAM	Controls flow from each layer of metabolic carbon to CO_2
PMES1(NL)			PARAM	Controls portion of metabolic E that decomposed to SOM with fast turnover
PMLCH	F_m		STATE	Proportion of surface soil covered by surface residue
PMN	n	F01,F07		Initial or fixed value of Manning's roughness coefficient. For element 1, becomes RMN(1) until a tillage operation.
PMSOL(CL,P)			PESTI	Amount of dissoved pesticide P in soil water in soil layer CL
PMNSEC(NL,E)			PARAM	Controls the nutrient material flow from parent material to mineral compartment

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
PNF(C)	n_m	D04	NUTRIN	Nitrogen content of plant C at maturity [kg/kg]
PNITRF			PARAM	Controls nitrification flow from NH_4 to NO_3
PNO(C)	n_o	D04	NUTRIN	Nitrogen content of plant C at emergence [kg/kg]
PNRAT(C)		D04	NUTRIN	Ratio of phosphorus to nitrogen in crop dry matter in crop C
PNU(C)			NUTRIN	Potential cumulative nitrogen uptake of crop C from soil [kg/ha]
POR(HL)		C02	SOIL	Porosity of horizon layer HL
PORCH			SED	Porosity of sediment eroded or deposited in channel
PORMAC			STATE	Macroporosity of surface resulting from tillage
PORPL			SED	Porosity of sediment eroded or deposited on field
POTHT(C)		D03	CROP	Potential mature height of crop C [m or ft]
POTY(C)		D02	CROP	Optimum yield of crop C [kg/ha or lb/ac]
PPARMN(E)			PARAM	Controls flow from parent material to mineral compartment
PPCV(C)		D03	CROP	Proportion of field surface covered by crop C at maturity
PPU(C)			NUTRIN	Potential cumulative phosphorus uptake by crop C [kg/ha]
PPULF(P)			PESTI	Amount of unwashable pesticide P on foliage
PPWLF(P)		E05	PESTI	Washable pesticide P on plant leaves [kg/ha]
PRF	P_u	G04	SED	USLE P factor for cropping practice
PRFF(K,L)		F10,F04	AHOP	USLE P factor on fixed (unmanaged) areas, element (K,L)
PRNC				Plant ratio of N to C
PROFD(K,L)			AHOP	Depth to erosion-resistant layer along element (K,L)
PROSL(J)		G02	SED	Proportion of particles by weight in particle-size class J
PRW(V,MO)	P_i	H05	RMETR	Markov transition probability in rainfall generator option, month MO: V = 1: case of wet day following wet day V = 2: case of wet day following dry day
PS1CO2(NL)			PARAM	Controls amount of CO_2 loss when structural C decomposes to SOM1, in residue layer NL
PS1S3			PARAM	Controls flow from soil organic matter with fast turnover to SOM with slow turnover
PS3S1			PARAM	Controls flow from soil organic matter with slow turnover to SOM with fast turnover
P1CO2A			PARAM	Intercept parameter that controls flow from soil organic matter with fast turnover to CO_2 (fraction of carbon lost to CO_2 when no sand is in the soil)
P1CO2B			PARAM	Slope parameter that controls flow from soil organic matter with fast turnover to CO_2
PS2S1			PARAM	Controls flow from soil organic matter with intermediate turnover to SOM with fast turnover
PS2S3			PARAM	Controls flow from soil organic matter with intermediate turnover to SOM with slow turnover
PS2CO2			PARAM	Controls flow from soil organic matter with intermediate turnover to CO_2
PS3CO2			PARAM	Controls flow from soil organic matter with slow turnover rate to CO_2
PSAND(HL)	f_s	C02	SOIL	Proportion of sand-sized particles in soil horizon HL

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
PSCO21			PARAM	Fraction of lignin flow (in structural decomposition) lost as CO_2
PSECMN(E)			PARAM	Controls flow from secondary to mineral N and P
PSECOC			PARAM	Controls flow from secondary to occluded P
PSECPT(E)				Controls flow from secondary to parent material for N and P
PSEV			STATE	Interval evaporation from plant-intercepted water [mm]
PSILT(HL)		C02	SOIL	Proportion of silt-sized particles in soil horizon HL
PSOLUB(P)		E05	PESTI	Solubility of pesticide P [g/T or ppm]
PSP(NL)			NUTRIN	Phosphorus sorption coefficient in nutrient layer NL
PSRO(P)	C_{ro}		IO	Amount of pesticide P in storm runoff
PSSO(P)			IO	Amount of pesticide P in the root zone soil
PTCV	F_s			Percent of soil area covered or protected by combination of plant and surface residue
PWT(L,J)			HOP2	Relative transportability of particle-class size J, in flow element L
QIRR		E17	MGMT	Rate of irrigation supply to total field [ft^3/s or m^3/s]
QIR			LOCAL	For border or furrow irrigation, upstream flow rate [m^3/min per m width]
QNLM			DRAT	Parameter in computation of draintile discharge
QPC	q_p		FLOWS	Peak outflow from channel or catchment [mm/min]
QPEST(Y,IP)		E16	MGMT	Amount of pesticide in application IP of year Y [kg/ha or lb/ac]
QPP	q_p		FLOWS	Peak runoff from distributed flow element [mm/min]
QRO	Q		FLOWS	Storm or daily runoff [mm]
R(D)		I	ACTDAT	Measured daily rainfall from record, hydrology option 1 [mm]
RA(MO)		H12		Average daily solar radiation for month MO [langley]
RAD(D)	R_i		RMETR	Measured or simulated mean solar radiation for day D [langley]
RAMX			RMETR	Maximum theoretical solar radiation for current day
RATE(Y,IF)		E14	MGMT	Application rate of manure in IF^{th} application of year Y [kg/ha or lb/ac if solid; mm or in if liquid]
RC(CL)	K_s	C02	SOIL	Soil-layer hydraulic conductivity of computational layer CL [mm/hr or in/hr]
RCB(CL)			SOIL	Hydraulic conductivity between layer CL and CL-1 [mm/min]
RCESTR(E)			PARAM	C/N and C/P ratios for structural material
RCES1(E)			PARAM	C/N and C/P ratios in soil organic matter with fast turnover
RCES2(E)			PARAM	C/N and C/P ratios in soil organic matter with intermediate turnover
RCES3(E)			PARAM	C/N and C/P ratios in soil organic matter with slow turnover
RCLM		E18		Mean flux limit of lower bound at DDIMP in draintile option [mm/hr or in/hr]
RCR(L,N)	R		AHOP	Hydraulic radius for furrow or channel overtopping, elements L, point N [m] (IHOP=2)

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
RD	R_i		RMETR	Generated daily value of solar radiation [langley]
RDM	pm/ppm			Relative dry matter production
RDP(C)		D02	CROP	Maximum root depth attained by plant C [mm or in]
RDPM				Maximum root depth of all crops in rotation
REFF				Effective rain (precipitation less interception) in option 1
REG(C)	τ		STATE	Relative daily plant growth determined by all stress sources, of crop C
RELP(P)		E05	PESTI	Relative rate factor of pesticide P for kinetic adsorption model
RESD	m_r			Total soil organic residue
RESIDC			TONCYC	Residue carbon added to nutrient layer NL
RESIDE(E)			TONCYC	Organic element E added to nutrient layer NL
RESLIG			TONCYC	Residue lignin added to nutrient layer NL
RF	P		FLOWS	Total storm rainfall [mm]
RFSURF	f_r		STATE	Current value of relative soil-surface roughness
RFT(T)	f_r	E03	MGMT	Relative soil-surface roughness resulting from tillage operation T
RFY	P		KEEP	Yesterday's rainfall [mm]
RGSURF	f_r	B02		Initial relative soil-surface roughness [mm]
RHOP(J)	ρ_s	G03	SED	Specific gravity of particle-size class J
RHOS	ρ_s		CSTATE	Overall soil specific weight [kg/L]
RI(MO)		H09		Relative peak 30-minute rain intensity (from record) for month M
RIN				Effective rainwater reaching soil surface, considering snowmelt or snow accumulation
RLIG		D02	CROP	Plant root lignin content
RLOSS		F11	PONDC	Rate of loss through bottom of pond, if different from RC(1) [mm/hr or in/hr]
RMD	R_i	H04	STATS	Annual mean daily net radiation on dry days [ly]
RMW	R_i	H04	STATS	Annual mean daily net radiation on wet days [ly]
RMN(L)	n		AHOP	Manning's n roughness coefficient for element L; either calculated from watershed characteristics or read from parameter file (see PMN) initially. Varies with tillage.
RMNF(K,L)	n	F04,F10	AHOP	Manning's n for fixed management strip (if any) within flow element L of condition K
RMU	n		FLOWS	Current value of Manning's n on flow element 1 (field surface)
RNC			NUTRIN	Nitrogen-carbon ratio, overall for plants
ROCON(P)	C_{pro}		IO	Concentration of pesticide P in runoff
ROOT(C)			STATE	Current value of root depth, crop C [mm]
ROPST(P)			PESTI	Pesticide P dissolved in runoff water [g/ha]
ROWF			HOP2	Inverse of row spacing [m^{-1}]
ROWSP		B02		Row spacing [m or ft]
RSDU(NL)			NUTRIN	Residue in layer NL
RSR	P			Rainfall in next storm from multiple storm breakpoint record
RSW(C)			STATE	Total soil water in current root zone of crop C [mm]
RTO(L)			SED	Ratio of soil grain roughness to total hydraulic roughness in flow element L
RWCF			PLOTS	Net relative water content in root zone
RWDT			AHOP	Width from center to center of furrows [m]
RYD	R_i			Total solar radiation yesterday [langley]

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
S1MNR(E)			PLOTS	Net mineralization due to decomposition of SOM1 (soil organic matter with fast turnover rate)
S2MNR(E)			PLOTS	Net mineralization due to decomposition of SOM2 (soil organic matter with intermediate turnover rate)
S3MNR(E)			PLOTS	Net mineralization due to decomposition of SOM3 (soil organic matter with slow turnover rate)
SCLAY			HOP1	Sum of clay particle portions in sediment particles
SCLOSA			PLOTS	Accumulated carbon lost from soil organic matter
SCLOSS			PLOTS	Carbon lost from soil organic matter each month
SDD(C)			STATE	Accumulated °C-days since planting for crop C
SDMPST(P)			PESTI	Mass of pesticide P associated with runoff sediment [g/ha]
SECNDY(E)			PLOTS	Secondary N and P
SEDMC	Q_s		FLOWS	Storm outflow of sediment from channel [tons/ha]
SEDMP	Q_s		FLOWS	Storm outflow of sediment from field [tons/ha]
SEDMPR			IO	SEDMP in terms of output units
SEEP			STATE	Interval outflow of water to below lowest root depth [mm]
SEED		H04		Random number generating seed value
SFAC			STATS	Conversion factor to produce desired output units
SH(CL)			SOIL	Difference measured along potential axis between sorption and absorption characteristic curves for soil layer CL [mm]
SL(K,L,N)	$S_o(x)$		AHOP	Local slope of flow path for element L, flow state K, at position N
SLA(K,L)	$\bar{S}_o$	F01,F07	AHOP	Overall slope of element L, for flow state K [m/m or ft/ft]
SLKF(K)	K_u		HOP1	Effective overall USLE K for flow path K
SLKP	$K_uL_uP_u$		HOP1	Combination of USLE slope-length factor, erodibility K, and P factor
SLRF(K,L)	ϕ	F04,F10	AHOP	Local soil-loss ratio for fixed or unmanaged part of field
SMEI			STATE	Accumulated storm EI since last tillage [mJ-mm/ha-hr]
SMX			HOP1	Conversion coefficient to obtain weighted S value for CN method
SNO	W_s		STATE	Water equivalent of surface accumulation of snow [mm]
SNREG(C)	τ_N		NUTRIN	Relative nitrogen growth-limiting stress coefficient of crop C. Varies from 0(fully stressed) to 1(no stress).
SOILIM	.		STATE	Maximum soil-water storage above an infiltration-limiting layer [mm]
SOLCLY			SED	Relative content of clay-sized particles in surface soil
SOLORG			SED	Relative content of organic matter in surface soil
SOLSLT			SED	Relative content of silt-sized particles in surface soil
SOLSND			SED	Relative content of sand-sized particles in surface soil
SOM1C			PLOTS	Carbon in soil organic matter with fast turnover rate

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
SOM1E(E)			PLOTS	N and P in soil organic matter with fast turnover rate
SOM2C			PLOTS	Carbon in soil organic matter with intermediate turnover rate
SOM2E(E)			PLOTS	N and P in soil organic matter with intermediate turnover rate
SOM3C			PLOTS	Carbon in soil organic matter with slow turnover rate
SOM3E(E)			PLOTS	N and P in soil organic matter with slow turnover rate
SOMSC			PLOTS	Sum of SOM1, SOM2, and SOM3 carbon (labeled and unlabeled)
SOMTC			PLOTS	Total soil-organic-matter carbon including structural and metabolic
SOMTE(E)			PLOTS	Total soil-organic-matter N or P including structural and metabolic
SP(S)		F03,F09		Specified slopes to define field profile slope at XSP(S) [m/m or ft/ft]
SPH(HL)		C03	NUTRI	Soil pH in horizon layer HL
SPL1			PARAM	Intercept parameter for metabolic (vs. structural) split
SPIN	X_m			Input to soil from snowmelt [mm]
SRESD		B02	STATE	Amount of surface residue [kg/ha or lb/ac]
SRSDU(HL)		C03		Initial incorporated plant residue in soil horizon
SSCLY		G03	SED	Specific surface of primary clay particles in surface soil [m^{-1} or ft^{-1}]
SSED			FLOWS	Specific surface of inorganic particles in sediment
SSILT				Sum of silt-particle portions in surface soil
SSMIN			SED	Specific surface of surface soil exclusive of organic material
SSORG		G03	SED	Specific surface of suspended organic material [m^2/m^3 or ft^2/ft^3]
SSSLT		G03	SED	Specific surface of primary silt particles in surface soil [m^2/m^3 or ft^2/ft^3]
SSSND		G03	SED	Specific surface of sand particles in surface soil [m^2/m^3 or ft^2/ft^3]
STDN			NUTRIN	Nitrogen content of standing dry plants [kg/ha]
STDP			NUTRIN	Phosphorus content of standing dry plants [kg/ha]
STDRY		B02	STATE	Standing dry matter from dead plants [kg/ha or lb/ac]
STEMP			PLOTS	Average soil temperature [°C]
STOLC			STATE	Precipitation-storage capacity of vegetation at current stage [mm]
STOLE			STATE	Amount of precipitation stored on vegetation [mm]
STOLM				Maximum precipitation storage of plants at full canopy [mm]
STOLR			STATE	Depth of water (intercepted) on plants and residue, if any, at start of rain [mm]
STRMNR(NL,E)			PLOTS	Amount mineralized due to decomposition of structural (since immobilization is required to decompose structural, these values will be negative)
STRUCC(NL)			PLOTS	Structural carbon
STRUCE(NL,E)			PLOTS	Structural N or P

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
SU(N)			SED	Slope at location N on plane or channel
SUMER			STATE	Accumulated field erosion since previous tillage
SUMNRS(E)			PLOTS	Annual accumulator for net mineralization from all compartments except structural
SUMPAIR(P)			PESTAB	Accumulated amount of pesticide P lost in harvest or into ambient air [kg/ha]
SUMPDK(P)			PESTAB	Accumulated amount of pesticide P lost to environmental decay [kg/ha]
SUMPIN(P)			PESTAB	Accumulated amount of pesticide P applied to field [kg/ha]
SUMPRO(P)			PESTAB	Accumulated amount of pesticide P washed off in runoff [kg/ha]
SUMPSEP(P)			PESTAB	Accumulated amount of pesticide P leached below root zone [kg/ha]
SUPL(L,J,N)			SED	Sediment supply rate at previous time step on element L, for particle-size class J, at node N
SW			STATE	Total soil water in root profile [mm]
SWIN			STATS	Soil water in profile at start of simulation [mm or in]
SWLD(MO)			STATS	Mean water content of root zone at end of month MO [mm/mm]
T(I)			HOP2	Time corresponding to breakpoint time-depth pair I of storm [min]
TA(MO)			RMETR	Mean monthly temperature [°C]
TAET	E_t			Total interval plant transpiration
TAMN(MO)		H11		Average daily minimum temperature for month MO [°C or °F]
TAMX(MO)		H10		Average daily maximum temperature for month MO [°C or °F]
TAREA(K,L)			LOCAL	Total area [m^2] contributing to downstream end of element L in flow state K
TAUC(L)	τ_c		SED	Current critical shear for erosion in flow element L [m^2/min]
TAUCF(KL,L)		F10		Critical shear for hydraulic erosion in channel fixed section
TBP(I)			HOP2	Breakpoint depths for I data pairs of first record (option 4) of next storm, used to decide if runoff carries over into next storm
TC	T_c			Mean generated daily temperature [°C]
TCERAT(E)			PLOTS	C/N or C/P ratio in soil organic matter
TCFMN(MO)			RMETR	Correction coefficient to make generated values of daily minimum temperatures consistent with optional input values of recorded local mean minimum temperatures for month MO [°C]
TCFMX(MO)			RMETR	Correction factor corresponding to TCFMN but for daily mean maximums during month MO
TCMAX(D)			RMETR	Mean daily maximum temperature calculated from monthly input data [°C]
TCMIN(D)			RMETR	Mean daily minimum temperature calculated from monthly input data [°C]
TCMN		J03	RMETR	Generated or measured daily minimum temperature [°C]
TCMX		J03	RMETR	Generated or measured daily maximum temperature [°C]

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
TCON			HOP1	Partial time of concentration from channel flow segment
TCS	T		STATE	Estimated driving temperature at soil surface [°C]
TCU			LOCAL	Limiting time allowed in surface routing based on current velocities at all points on surface
TDLTA			SEDCH	Total of DLTA(J) for all J
TDRY			PESTI	Interval between surface additions of water to soil profile [days]
TDSN(MO)			STRESS	Number of stress-days due to limited nitrate in month MO
TDSW(MO)			STRESS	Number of stress-days for current crop due to limited water in root zone during month MO
TE				Time of ending of storm [min]
TELAP				Duration of storm [min]
TEVAP(MO)			STATS	Total evaporation from soil surface for month MO [mm]
TGBM(C)	T_b	D03	CROP	Minimum growth temperature for plant C [°C or °F]
TGOP(C)	T_{op}	D03	CROP	Optimum growth temperature for plant C [°C or °F]
TH(CL)	θ		STATE	Soil-layer water content by volume (θ) [cm^3/cm^3]
THE(CL)	Θ		STATE	Normalized water content (fraction of available) in layer CL, defined as $\theta_e = (\theta-\theta_r)/(\theta_s-\theta_r)$
THEC	θ_c		BOTH	Critical normalized water content, below which water uptake by plants is curtailed
THEM(CL)			SOIL	Maximum normalized soil-water content by layer
THEMTH		E01	MGTH	Normalized soil-water content (THE) above which management is delayed until next day
THER(C)			STATE	Overall normalized soil-water content in current root zone of plant C
THIRR		E17	MGMT	Critical normalized soil-water content for starting irrigation by demand method [mm/mm or in/in]
THR(CL)	θ_r		SOIL	Residual layer soil-water content inactive capillary water
THRESH		A02	IO	Storm summary output file threshold for stormwise output from infiltration model (IHOP=2): depth of rainfall below which output is NOT wanted. For example, in English units, 0.01 would probably produce output from all storms, while 2.0 or 3.0 would yield only large storms.
THRZ			HOP2	Residual water content in surface infiltration zone
THS(CL)	θ_s	C02	SOIL	Layer soil-water content at saturation
THST	θ_i	B02		Starting water content of soil profile [mm/mm or in/in]
THSZ	θ_s		HOP2	Soil-water content of infiltration control zone at 0 head
THW(CL)	θ_{15}		SOIL	Wilting-point water content (15-bar tension) of soil layer
TIM	Δt_m			Time interval [min] for snowmelt calculation
TIME			PLOTS	Time [yr]
TIRR		E17	MGMT	Total amount of annual irrigation-ditch water supply [mm or in]
TITLE(v,20)		A01	STATS	Hollerith title from parameter file; v is index for card number(1 to 3), 20 indicates twenty 4-character words per card

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
TLAI	F_{LT}			Total combined present leaf-area index
TMAX			PARAM	Maximum temperature for decomposition
TMINRL(E)			PLOTS	Total mineral nutrient content 1 = ammonium 2 = labile phosphorus
TMSNO(MO)			STATS	Total monthly amount of snowmelt [mm or in]
TN		H03	RMETR	Annual mean value of daily minimum temperatures at given location [°F or °C]
TN2			NUTRIN	Total volatile N_2 lost from soil
TNETMN(E)			PLOTS	Annual accumulator for net mineralization from all compartments
TNO3				Total soil profile nitrate-N content
TODR(MO)			STATS	Total amount of water drained through draintiles, month MO [mm]
TOPERC(MO)			STATS	Total monthly amount of seepage to below root zone
TOPT			PARAM	Optimum temperature for decomposition [°C]
TORGN				Total amount of organic nitrogen in root soil profile
TOTALC			PLOTS	Total carbon in system (including sources and sinks)
TOTALE(E)			PLOTS	Total N or P in system (including sources and sinks)
TOTEP			STATS	Annual total actual evapotranspiration
TOTET(MO)			STATS	Monthly total actual evapotranspiration
TOTNLCH(MO)			STATS	Monthly total nitrate-N leached below roots [kg/ha or lb/ac]
TOTNRO(MO)			STATS	Monthly total nitrogen in runoff [kg/ha or lb/ac]
TOTP(HL)		C03		Total P content in soil horizon HL [kg/ha or lb/ac]
TOTPEP			STATS	Annual total potential ET [mm or in]
TOTQ(MO)			STATS	Monthly total runoff [mm or in]
TOTR(MO)			STATS	Monthly total rainfall [mm or in]
TOTSD(MO)			STATS	Monthly total sediment production [t/ha or tn/ac]
TPSDK(P,MO)			PESTAB	Total pesticide P decayed by end of month MO, [g/ha]
TPSEP(P,MO)			PESTAB	Total pesticide P lost to seepage by end of month MO [g/ha]
TPSIN(P,MO)			PESTAB	Total pesticide P applied to field by end of month MO [g/ha]
TPSLA(P,MO)			PESTAB	Total pesticide P lost in air and harvest by end of month MO [g/ha]
TPSRO(P,MO)			PESTAB	Total pesticide P washed off in surface runoff by end of month MO [g/ha]
TPSRS(P,MO)			PESTAB	Total pesticide P remaining in plant, soil, and residue at end of month MO [g/ha]
TP05		H13	HOP1	30-minute rain depth with 10-year return period [mm or in]
TP6		H13	HOP1	6-hour rain depth with 10-year return period [mm or in]
TS				Time of start of storm [min], from midnight
TSC			HOP1	Constant portion of flow concentration time formula used with variable RMN and TCON
TSHL			PARAM	Shape parameter to left of optimum temperature (for decomposition)
TSHR			PARAM	Shape parameter to right of optimum temperature

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
TSL(CL)	T		SOIL	Soil layer temperature [°C]
TSNO			STATE	Age of snowpack [days]
TSR				Time of start of next storm for multiple-storm record
TSTEP			CSTATE	Time step of transport computations [min]
TT(I)			HOP2	Breakpoint times for first record of next storm (see TBP(I)) [in minutes since midnight of start day]
TTRANS(MO)			STATS	Total transpired water from plants for month MO [mm]
TW(N)			SED	Top width of water surface at section N [m]
TWDN			NUTRIN	Total annual denitrification in soil profile [kg/ha]
TWIM			NUTRIN	Total annual immobilization in soil profile [kg/ha]
TWMN			NUTRIN	Total annual mineralization in soil profile [kg/ha]
TXMD		H02	RMETR	Annual mean value of daily maximum temperatures on dry days [°F or °C]
TXMW		H02	RMETR	Annual mean value of daily maximum temperatures on wet days [°F or °C]
TYAV			SOIL	Annual average air temperature [°C]
TYD				Maximum air temperature yesterday [°C]
U(N)	u		SED	Velocity of surface water at node N [m/min]
UFAC			STATS	Conversion factor to prepare output for selected units
UL(N)	u		SED	Velocity of surface water at last time step at node N [m/min]
URMX			LOCAL	Maximum value of difference in flux between computational nodes in surface routing calculations. Used in determining time-step size.
US			BOTH	Maximum amount of stage-1 soil evaporation [mm]
USK(J)	K_u	F06		USLE K for zone from XKS(J-1) to XKS(J) [t-hr/MJ-mm]
USLK(K,N)	K_u		AHOP	USLE soil K parameter (appropriate English or metric dimensions) on field surface for flow state K at node N
VARAT1(V,E)			PARAM	Variable ratio data for SOM1. E is element and represents N or P: V=1: maximum C/E ratio for material entering SOM1 V=2: minimum C/E ratio for material entering SOM1 V=3: amount of mineral element present when minimum ratio applies
VARAT2(V,E)			PARAM	Variable ratio data for SOM2: V=1: maximum C/E ratio for material entering SOM2 V=2: minimum C/E ratio for material entering SOM2 V=3: amount of mineral element present when minimum ratio applies
VARAT3(V,E)			PARAM	Variable ratio data for SOM3 V=1: maximum C/E ratio for material entering SOM3

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
				V=2: minimum C/E ratio for material entering SOM3 V=3: amount of mineral element present when minimum ratio applies
VIN			CSTATE	Volume of inflow water [mm] (+ or -)
VIP			CSTATE	Volume of outflow water [mm] (+ or -)
VLOSSG			PARAM	Fraction of gross mineralization that is volatilized
VOLEX			PLOTS	N that was volatilized as a function of nitrogen remaining after uptake by plants
VOLEXA			PLOTS	Accumulator for VOLEX
VOLGM			PLOTS	N that was volatilized as a function of gross mineralization
VOLGMA			PLOTS	Accumulator for VOLGM
VNU	υ		CONS	Kinematic water viscosity [m^2/s]
VQDR			DRAT	Water flowing out draintiles during computation
VS(J)	v_s		SED	Settling velocity of particles in size class J [m/s]
W(L,N)	W		AHOP	Width of flow element L at node N [m]
WATI			CSTATE	Initial water storage in layer [mm]
WATN			CSTATE	Final water storage in layer [mm]
WB(L,N)			AHOP	Width of bottom of flow section or furrow [m]
WDFXA			PLOTS	Accumulator for atmospheric nitrogen fixation
WF(CL)			HOP1	Weighting function for effect of soil-layer water content on effective curve number
WFRW(T)		E03	MGMT	Width of furrows resulting from cultivation T [m or ft]
WFT(C)			STATE	Dry weight of fruit and/or seed of plant C at current stage [kg/ha]
WI(MO)			HOP1	Weighting value for relative historical rainfall intensities for month MO
WINIT		F07		Initial width of channel bottom at outlet: 0 = triangular section <0 = a "naturally eroded" rectangular section, width = |WINIT| [m or ft]
WL(CL)			SOIL	Weight of soil in soil layer CL [kg/ha]
WLCH			STATE	Interval amount of nitrate-N leached below roots [kg/ha]
WLO(HL)			NUTRIN	Fraction of nutrient material in soil horizon HL that is considered part of active microbial zone
WLV(C)	pm_{lv}		STATE	Current mass of leaves and stems of plant C [kg/ha]
WNH4(CL)			NUTRIN	Ammonium-N content of soil layer CL [kg/ha]
WNHLR	.		IO	Total NH_4 nitrogen in runoff [kg/ha]
WNL(NL)			NUTRIN	Weight of soil in nutrient layer NL [kg/ha]
WNO3(HL)		C03	NUTRIN	Amount of nitrate-N in horizon layer HL [g/t or ppm]
WNORG(CP,NL)			NUTRIN	Mass of organic nitrogen in pool CP, nutrient layer NL [kg/ha]
WNOUT			IO	NO_3 nitrogen in runoff [kg/ha]
WOOD(C)			STATE	Dry mass of wood in perennial woody plant C [not now used]
WPLAB(HL)	C03		NUTRIN	Amount of labile phosphorus in horizon layer HL [g/t or ppm]
WPLRO			IO	Labile phosphorus in runoff, total

NAME	VOL I. NAME	INPUT (Line ID)	COMMON BLOCK	DEFINITION
WRT(C)	pm_r		STATE	Dry weight of root mass of plant or crop C at current time [kg/ha]
WSF(J)			SED	Estimated relative erodibility weighting of particle-size class J
WTDH2O			CONS	Weight of water [N/m³]
WTF(N)			AHOP	Width at top of furrow at location N [m]
WTP	W			Width of field element at top [m]
XD(K,L,N)			AHOP	Distance from upstream point to location N, flow state KL, element L [m]
XDI				Distance up from bottom of field element [m]
XKS(J)		F06		Distance along XLP to lower end of zone having soil with USLE K of USK(J) [m or ft]
XLC	L_c	F07		Length of channel element for topographic state [m or ft]
XLFS		F04,F10		Distance from upstream end to start of area having fixed (unmanaged) condition [m or ft]
XLFE		F04,F10		Distance from upstream end to end of area having fixed (unmanaged) condition [m or ft]
XLP	L_p	F01		Length of field element for topographic state [m or ft]
XSP(S)		F03,F09		Locations on field element where slope S is specified [m or ft]
YALCON			CONS	Constant in Yalin relation for sediment transport capacity
YLC			RMETR	Cosine of location latitude
YLS			RMETR	Sine of location latitude
YMX(L,N)			AHOP	Storm maximum of flow depth reached in element L, location N [m]
YPEV				PEV on previous day
ZC(K,L)			AHOP	Side slope of channel element L,(H:V), topographic state K
ZCA(K,L)		F07		Normal channel sideslope for topographic state K and channel element L
ZSF		B02		Initial row sideslope, H:V
ZQ	h_z	F11	PONDC	Depth of water in impoundment below which no outflow occurs [m]

Appendix F. Information on Opus Subprograms

Routine	File	Called By	Called When	Description of Process
ADVWL	HYDRL	RFXS	Each Δt during storm, for IHOP=2	Traces advance of wetting front through various soil layers during a rainfall infiltration event.
ANSTAT	STAT	GRIND	Yearly	Prints annual summary output table.
BETAG	DAILY	RANBET	When stochastic CN option chosen, daily	Generates a value having a beta probability distribution given a mean and variance, and a uniformly distributed random variable.
BLKDAT	PRELM	[BLOCK DATA]	Initially	Initializes some data in labeled common blocks.
BRAKS	PRELM	SETLAY	Initially, for each soil horizon	Sets default values for soil characteristic parameters based on regression relations developed by Rawls and Brakensiek, which use soil texture and porosity as independent variables.
BRATHS	PRELM	SETLAY	Initially, for each soil horizon	Sets default value, if required, for saturated water content based on Rawls and Brakensiek's regression on porosity and texture.
CAPACY	SED	SEDCOM	Breakpoint option, during storm, each Δt, each Δx	Computes sediment-transport capacity along each node point of surface flow.
CELF	PRELM	GETMET	Initially, if INUN=2	Converts °F to °C.
CFACT	MAIN	GRIND	Daily	Calculates Laflen/Foster USLE C factor daily.
CHECK	READ	MAIN READA/B CROPIN MGRIN FKSL GETMET	For each line in data file	Checks input parameter and meteorological data records for correct sequencing: reads id code from each record and tests against expected record code.
CHEMFL	CHEM	SOILMV	Daily or interstorm	Determines sources, sinks, and layerwise hierarchy for computation of chemical concentration changes due to water fluxes.
CHEMTAB	STAT	GRIND	Monthly	Fills reporting arrays for end of year report on fate of each pesticide.

Routine	File	Called By	Called When	Description of Process
CHMTRF	CHEM	CHEMFL	Daily or interstorm, once for each soil component layer	Calculates chemical transfer between layers after daily water throughflow has been found for each computational layer.
CNRO	DAILY	GRIND	On each rain day for IHOP=1	Calculates daily runoff volume and peak from daily rainfall using modified SCS Curve Number technique.
READA/ READB	READA/ READB	OPUS2	Initially	Reads all input parameters and generates necessary computational arrays and initial state variables for simulation run.
CROPIN	IOAUX	READA	Initially	Reads input data describing all crops used in simulation.
CULTIV	NUTRS	SIMSOM	Daily, when any residue additions occur, for IFNUT>0	Mixes surface litter into topsoil layer when cultivation occurs.
CYCLE	NUTRS	SIMSOM	Daily for IFNUT>0	Determines decomposition factor related to temperature and water. Initializes mineralization variables.
DCFLUX	CHEM	CHMTRF SOILAD	Once for each layer, each solute, and each time step	Computes chemical transfer between adjacent soil elements for non-adsorbed solutes or equilibrium sorption solutes.
DECOMP	NUTRS	SIMSOM	Daily, for IFNUT>0	Calculates nutrient decomposition flows.
DETCUL	NUTRS	DECOMP	Daily, for IFNUT>0	Flags cultivation-event days.
DISTN	WTHR	TRGEN FGENR	Daily for IHOP=1 once each for T & R	Computes pseudorandom number values according to normal probability distribution.
DOV	POND	SPOND	During each Δt during storm	Computes impoundment depth given a value of stored volume.
DSEFH	SOIL	SOILMV	As needed during each iteration	Calculates slope of hydraulic characteristic in reduced theta.
DTDF	MAIN	GRIND	Each interstorm period, for IHOP=1 or daily, for IHOP=2	Calculates effective evaporation interval.

Routine	File	Called By	Called When	Description of Process
ELFLOW	NUTRS	DECOMP	For each residue pool, daily	Decompose from "box a" to "box b," depending on C:N ratio.
ENRCMP	SERV	RFXS	End of each runoff event	Computes enrichment of fine particles in sediment at field outlet.
EQSAND	PRELM	READB	Initially	Computes equivalent sand diameter for all particle classes.
EROSN	NUTRS	SIMSOM	Daily, IFNUT>0	Removes residue material from system during nutrient model simulation.
EVAP	WTHR	GRIND	Daily	Assigns transpiration and soil evaporation from PET for all plants (up to four) for current day, given a value of potential total ET and plant state.
EXCH	SERV	PORDER	Once each call to PORDER	Companion to PORDER, used to reassign the particle-class characteristics when they are reordered by equivalent sand diameter.
FDEC	CHEM	FLASH SOILAD	Frequently, as needed (varies)	Decay function related to linear storage model of chemical concentration changes with flow through a soil element.
FEXR	CHEM	SHOVQ	As required by SHOVQ	Exponent of ratio of two numbers; prevents underflow.
FGENR	WTHR	WGENR	Daily	Generates daily radiation and maximum and minimum temperatures.
FHOSE	SOIL	SETLAY SOILMV SOILAD HAWOOD	Frequently, during soil water computations	Computes soil matric tension as a function of normalized water content: the function $H(\theta_n)$ [see FSOH].
FINFL	HYDRL	RFXS	Each Δt during runoff-producing storms, for IHOP=2	Calculates mean infiltration rate in time step as function of current infiltrated depth.
FKBAR	PRELM	SETLAY	Initially, for each computational soil layer	Computes mean effective internodal soil hydraulic diffusive conductivity.
FKDCL	PRELM	SETLAY	Initially, during read process	Estimates adsorption coefficient for inorganic molecules as a function of soil clay content.
FKSL	IOAUX	READA	Initially, during read process	Assigns local value of USLE K to each surface flow distance node point.

Routine	File	Called By	Called When	Description of Process
FLASH	CHEM	GRIND RGATE	Daily, when runoff occurs	Calculates amount of dissolved and adsorbed mineral nutrient material in runoff from soil, residue, and plant-surface washoff.
FLAYP	HYDR	RFXS	Breakpoint each Δt during runoff computations, for IHOP=2	Calculates effective net soil hydraulic conductivity during infiltration into a crust-topped profile.
FLOCLR	NUTRS	PRELIM FLOWUP	Each day for IFNUT>0	Clears nutrient flow arrays.
FLOW	NUTRS	RESPIR DECOMP ELFLOW RESLOS	Daily for IFNUT>0	Stores a nutrient flow amount in the appropriate array.
FLOWUP	NUTRS	SIMSOM	Daily for IFNUT>0	Updates nutrient-state variables from the flow arrays.
FMANN	SERV	READA GRIND	On days when management changes to surface occur	Calculates net Manning's n from bare soil n value and surface condition.
FMLCH	SERV	READB FMANN UPDATE HAWOOD	Daily as required by each module	Calculates net soil mulch cover as a function of weight per unit area of surface residue.
FONE	CHEM	RKSORB RNGKTA	For each Δt and each layer in profile	Solves difference equation for change in dissolved pesticide for kinetic adsorption case for a given state.
FROQ	SERV	SURF RFXS	Once each Δt during runoff or furrow irrigation	Calculates value of hydraulic radius given section hydraulic properties and discharge.
FSHF	WTHR	TIMELT	Occasional; daily when snowmelt is fast enough to cause runoff	Reduces daily time to angular shifted scale in radians, for use in snowmelt calculations.
FSL	SERV	GRIND READA FKSL	Only when CN factors change, for IHOP=1	Calculates slope-length factor.

Routine	File	Called By	Called When	Description of Process
FSOH	SOIL	READA GLAY SETLAY SOILMV INTFG GLAY FLAYP	Frequently as needed	Computes normalized water content for a given soil as a function of matric potential: the function $\theta_e(H)$ [see FHOSE].
FSUNM	SERV	OPUS2 DTDF	Daily	Calculates solar day length for a given latitude and time of year.
FVT	SERV	SURF	Each Δt, each Δx, and iteration	Wave-advance-estimating function for explicit estimate of new water-surface depths during surface water routing.
FXNU	SERV	READB SUMST OPUS2 GRIND	Daily and at initialization	Calculates kinematic viscosity (m^2/sec) as a function of water temperature (°C).
GAMA	DAILY	CNRO	Daily for IHOP=1	Finds gamma distributed pseudorandom number.
GAMMA	DAILY	BETAG	Daily for IHOP=1	Gamma function, used for getting BETA distribution function.
GETLIG	NUTRS	SIMSOM	Daily for IFNUT>0	Calculates fraction of structural residue that will be lignin.
GETMET	IOAUX	READB	Once during initialization	Reads meteorological data records: monthly means and standard deviations of temperature and radiation.
GLAY	HYDR	RFXS	For IHOP=2 during each rain rate step	Computes net effective estimated capillary drive for current conditions of rain rate and infiltrated depth under crusted-soil conditions.
GONE	OCHEM	RNGKTA	Frequently, for kinetic option only	Finds current value of rate of change of adsorbed pesticide for given layer, during kinetic transport option.
GRIND	MAIN	OPUS2	Once	Drives Opus simulation through daily cycle.
HAWOOD	CROP	GRIND	Daily	Performs all management operations and calculates all resulting physical changes.
HYFILE	STAT	RFXS DAILY	Each Δt, but only for rainfalls that exceed set threshold	Produces optional detailed hydrologic output file.

Routine	File	Called By	Called When	Description of Process
IDAY	SERV	OPUS2 MGRIN JULDT	Daily, depending on IFJUL	Finds Gregorian day given month, day of month, and days/year.
INTFG	MAIN	OPUS2 GLAY	Once at start and when soil crust conditions change	Calculates integral soil infiltration capillarity parameter from soil hydraulic parameters.
JULCON	MAIN	OPUS2 READUP READBP	Each storm; for IHOP=2	Converts integer representing date as MMDD plus integer YY into Gregorian day GGG plus integer representing YYGGG.
JULDT	SERV	OPUS2 GRIND JULCON	Daily, depending on IFJUL	Converts integer representing MMDDYY into integer representing Gregorian day GGG and year YY as YYGGG.
LEAP	SERV	READA OPUS2 GRIND JULDT	Each year of simulation	Finds number of days per year.
LEAVES	CROP	HAWOOD UPDATE	Daily	Distributes daily value of plant photosynthetic production among leaf/stems, roots, and fruit.
METRCM	NUTRS	DECOMP	Daily for IFNUT>0	Scales down flow from metabolic if contents are exceeded.
MGRIN	IOAUX	READA	Once at beginning	Reads all management schedules and menus.
MONDAY	SERV	READA/B GETMET GRIND	365 times at start, plus once/day	Finds month, day, and year associated with a given Julian day and year.
NCYCL	NUTRS	GRIND	Daily	Computes carbon, nitrogen, and phosphorus cycle changes within residue and top 20-cm soil layers over a given time interval (usually 1 day).
NPINIT	NUTRS	PRELIM	Once at start	Initializes N or P in soil organic matter.
OPUS2	MAIN	OPUSG		Opus driver (main program).
PARTIT	NUTRS	PRELIM SIMSOM	At start and daily given IFNUT>0	Partitions residue into nutrient layer 1 of structural and metabolic.
PENMAN	WTHR	TRGEN GETMET	Daily	Computes modified Penman-Montieth potential evapotranspiration.

Routine	File	Called By	Called When	Description of Process
PERIM	SERV	SURF FROQ	Each Δt, iteration, and Δx for IHOP=2	Calculates hydraulic flow cross-section properties as a function of hydraulic radius, including top width, wetted perimeter, and rate of change of such properties.
PESTDK	CHEM	GRIND	Daily	Calculates daily pesticide decay in root zone.
PESTMV	CHEM	SOILAD	On days with rainfall	Calculates transition of pesticides on the plant and soil surface, including decay and washoff.
PORDER	PRELM	READB	Once at start	Reorders sediment-particle classes according to increasing equivalent sand diameters.
PLAY	HYDR	RFXS	Each Δt during runoff for lHOP=2	Finds ponding depth and modified G and K parameters for layered profile infiltration.
PRELIM	IOAUX	READB	Once at start for IFNUT>0	Initializes nutrient state variables and many parameters not set in BLOCK DATA.
PRTCMP	PRELM	READB	Once at start	Generates default sediment particle-size classes given sand/silt/clay contents.
QOD	POND	SPOND	Each Δt for IFPOND>0 and IHOP=2 during runoff events	Calculates outflow discharge of an impoundment as a function of impoundment depth.
RANBET	DAILY	CNRO	Each runoff day for IHOP=1 and IFRNCN>0	Calculates beta-distributed pseudorandom numbers.
RANDN	WTHR	TRGEN CNRO SMUSLE GETMET GAMA RFGN FGENR	Daily plus once more if IHOP=1 and when no real runoff data used	Generates a uniformly distributed pseudorandom number between 0 and 1.
READBP	MAIN	GRIND	Once each storm for IHOP=2	Reads breakpoint rainfall data.
READUP	MAIN	OPUS2 READBP	Once each storm for IHOP=2	Reads first five breakpoints of next storm to see if gap between storms is too small to treat the two storms as hydrologically separate.
READTM	READA	READA/B	Daily during data read, for each template heading	Reads past template headings in data input method.

Routine	File	Called By	Called When	Description of Process
RECROP	CROP	GRIND	At end of each year	Resets crop ID parameters at end of crop rotation year.
RESLOS	NUTRS	EROSN	For IFNUT>0, and only on runoff days	Computes residue lost to erosion.
RESPIR	NUTRS	DECOMP	Daily for IFNUT>0	Computes flows associated with microbial respiration.
RFGN	WTHR	TRGEN	For IFGEN>0, and only on rainfall days	Computes amount of gamma-distributed daily rain.
RFXS	HYDR	GRIND RGATE	For each rainfall event when IHOP=2, plus each irrigation	Performs hydrologic computations in space and through time during runoff, including erosion and sediment transport for all particle classes.
RGATE	CROP	HAWOOD	For each irrigation	Carries out sprinkler or furrow irrigation, including routing of flow across surface and addition of water and chemicals to unsaturated profile.
RICHET	WTHR	EVAP	Daily	Calculates daily plant and soil evaporation from daily PEV given ALAI and soil-evaporation history.
RILLGM	SERV	RFXS	At end of each runoff storm for IHOP=2	Computes estimated changes in flow section profile geometry, resulting from local amount of erosion or deposition.
RKSORB	CHEM	CHMTRF SOILAD	For each chemical, each layer, and each day and for each rainfall input pulse	Calculates transport of kinetically adsorbed solute through a finite difference layer given inflow, outflow, and initial conditions. Analogous to DCFLUX for equilibrium adsorbed solutes.
RNGKTA	CHEM	RKSORB	For each Δt, from each RKSORB call (see above)	Solves pair of differential equations in x, y, t over interval dt for changes in x and y, using Runge-Kutta method.
ROOTDK	CROP	UPDATE	Daily during crop senescence	Calculates root decay and adjusts appropriate nutrient mineral and organic pools.
RTHF	SOIL	SOILMV	Once each day or interstorm interval, and for each layer and Δt	Obtains mean diffusive relative hydraulic conductivity between two points in a soil, by calculating first moment of the power function of normalized water content.

Routine	File	Called By	Called When	Description of Process
SAVARP	NUTRS	NCYCL PRELIM	Daily, for IFNUT>0	Saves variables for printing or plotting.
SEDCOM	SED	RFXS	For IHOP=2 during each Δt during storm runoff	Computes sediment erosion and transport over space and time.
SETLAY	PRELM	READA	Once at setup	Divides soil horizons into computational layers and nutrient cycle layers, and initializes all necessary parameter arrays.
SETPAR	NUTRS	--	Used only if IFNUT>0	BLOCK DATA to set nutrient parameter values.
SETSL	PRELM	READA	Once at setup for each hydraulic element	Interpolates between given data points to determine local values of profile slope at each computational node along surface flow path.
SHADE	SERV	READB RICHET UPDATE	Daily	Calculates relative total soil shade due to plants at any value of LAI.
SHIELD	SERV	CAPACY	Each Δt for each particle size	Calculates critical shear value for given particle size.
SHOVQ	CHEM	DCFLUX	Frequently, for chemical transport calculations	Calculates equation for solution of differential equation for final outflow concentration of a linear "reservoir" subjected to inflow, outflow, and change of storage with arbitrary inflow concentration.
SIMSOM	NUTRS	NCYCL	Daily	Calculates flow of below-ground N and P.
SLFILE	STAT	GRIND	At each N day as set by user	Produces optional detailed soil-layer information.
SLOPE	SOIL	SOILMV	Each iteration during each Δt and each Δz	Finds slope of water content-pressure curve.
SMUSLE	DAILY	CNRO	For IHOP=1 and for runoff events	Sediment yield estimated by James Williams' MUSLE.
SNOWF	WTHR	GRIND	Daily when temperature drops below 0 C	Calculates estimated snow accumulation and melt.

Routine	File	Called By	Called When	Description of Process
SOILAD	SOIL	GRIND RGATE	Daily (IHOP=1) or after each rain (IHOP=2)	Computes soil saturation profile from a given surface input, and transports dissolved substances into soil profile with input water.
SOILMV	SOIL	GRIND	Daily or between storms	Redistributes unsaturated soil water in soil profile between storms using Richards' equation solved by explicit SF method.
SOLTM	SOIL	GRIND	Daily	Computes daily soil temperatures at each layer using heat-diffusion equation.
SOLV	SOIL	SOILMV SURF SOLTM	Each Δt and iteration for SOILMV and SURF; and each day for SOLTM	Does the matrix solution for tridiagonally dominant matrix equation.
SOMLOS	NUTRS	EROSN	Daily for IFNUT>0	Computes soil loss of SOM1, SOM2, SOM3 (nutrients).
SPIF	HYDR	PLAY	Each Δt during storm, for IHOP=2	Finds infiltrated depth F as a function of G, r, and K in Smith-Parlange infiltration expression.
SPLASH	SED	SEDCOM	Each Δt during storm for IHOP=2	Computes splash (interrill) erosion from a given rainfall rate and soil surface conditions.
SPOND	POND	RFXS	For IHOP=2 and each Δt during storm	Routes hydrograph and sediment pattern through a given impoundment.
SUMCOL	NUTRS	FLOWUP	Daily for IFNUT>0	Calculates sum of elements of a given column in an NxN array.
SUMLAY	NUTRS	NCYCL	Daily for IFNUT>0	Sums nutrients in top 20 cm of computational layers.
SUMROW	NUTRS	FLOWUP	Daily for IFNUT>0	Calculates sum of elements of a given row in an NxN array.
SUMST	STAT	GRIND ANSTAT RGATE	Daily or interstorm or irrigation event	Keeps account of statistical data for output information summary.
SURF	HYDR	RFXS	Each Δt during runoff for IHOP=2	Routes surface and channel flow from uniform or upstream input using kinematic wave or diffusive wave method, depending on Woolhiser parameter.

Routine	File	Called By	Called When	Description of Process
THERAD	WTHR	TRGEN GETMET	365 times during data read, and then daily	Computes daily potential incoming solar radiation latitude and time of day.
TIMELT	WTHR	GRIND	Only on days of estimated snowmelt	Based on assumed sinusoidal distribution of melt rate during daylight, divides melt interval into 10 parts and estimates a melt rate for each part based on total melt of snow on snowmelt days.
TINTF	WTHR	TIMELT	Only on estimated melt days	Integral along radian scale of shifted sine function.
TPFUNC	CHEM	PESTDK	Daily for each pesticide	Calculates temperature-effect parameter for pesticide-decay function.
TRGEN	WTHR	OPUS2 GRIND	Daily	Produces daily meteorological values from monthly summary data or from a statistical/probabilistic weather model.
UPDATE	CROP	READB GRIND	Daily	Computes daily growth changes in plants from meteorologic, soil condition, and plant parameters.
UPTAKE	CHEM	SOILMV	Daily during plant growth	Accounts for plant uptake of nutrients on daily or less frequent time step for all layers in which soil solution is found and into which roots have penetrated.
VOD	POND	SPOND	Whenever SPOND is called	Computes impoundment storage volume as a function of maximum depth.
VSETL	SERV	READA SUMST OPUS2	Once, plus daily whenever kinematic viscosity changes	Computes particle-settling velocity as a function of effective diameter, specific gravity, and water kinematic viscosity.
WFUNC	SERV	MGRIN PESTDK	Once initially and then daily	Calculates value of water-effect parameter for pesticide-decay function.
WGENR	WTHR	TRGEN GETMET	365 times during initializing, then daily.	Generates daily temperatures and radiation.

Appendix G. COMMON Block-Subroutine-File Associations

OPUS COMMON BLOCK - SUBROUTINE - FILE ASSOCIATIONS

OPUS FILES

COMMON BLOCK	OMAIN	OGRIND	OREAD*	IOAUX	OPRELM	OSOIL	OHYDR	OSED	ODAILY	OCROP	OCHEM	ONUTRS	OWTHR	OPOND	OSERV	OSTAT
ACTDAT	OPUS2	GRIND READUP READBP	CREAD		BLKDAT		CNRO						TRGEN			
AHOP	OPUS2	GRIND CFACT	CREAD	FKSL			RFXS SURF	SPLASH SEDCOM							RILLGM FROQ PERIM	
ARRAYS								BETAG								
BOTH			CREAD			SOILAD							RICHET			
CHARL	OPUS2	GRIND INTFG	CREAD		BRAKS SETLAY	SOILMV FSOH FHOSE DSEFH SOILAD SLOPE	RFXS FLAYP			HAWOOD						
COMPUT				PRELIM								CYCLE DECOMP ELFLOW NCYCL PARTIT RESPIR SAVARP SIMSOM				
CONS	OPUS2	GRIND CFACT	CREAD	BLKDAT EQSAND				CAPACY							FMANN VSETL	SUMST
CROP		GRIND	CREAD	CROPIN MGRIN						HAWOOD UPDATE LEAVES	FLASH					

OPUS FILES (Continued)

COMMON BLOCK	OMAIN	OGRIND	OREAD*	IOAUX	OPRELM	OSOIL	OHYDR	OSED	ODAILY	OCROP	OCHEM	ONUTRS	OWTHR	OPOND	OSERV	OSTAT
CROP										ROOTDK RECROP						
CROPC		GRIND	CREAD	CROPIN MGRIN						HAWOOD UPDATE LEAVES ROOTDK RECROP	FLASH					
CSTATE						SOILAD DCFLUX					CHMTRF RKSORB FONE					
DRAT			CREAD			DRAINF										SUMST
FLOVAL												FLOCLR FLOW FLOWUP				
FLOWS	OPUS2	GRIND	CREAD			SOILMV	RFXS CRUSK		CNRO SMUSLE	HAWOOD RGATE	FLASH PESTMV			SPOND		SUMST HYFILE
HOP1		GRIND	CREAD	GETMET					CNRO SMUSLE							
HOP2	OPUS2	GRIND READBP READUP	CREAD		SETLAY BLKDAT		RFXS GLAY PLAY	SEDCOM		HAWOOD						
INFILC							RFXS GLAY PLAY ADVWL RESTH									

OPUS FILES (Continued)

COMMON BLOCK	OMAIN	OGRIND	OREAD*	IOAUX	OPRELM	OSOIL	OHYDR	OSED	ODAILY	OCROP	OCHEM	ONUTRS	OWTHR	OPOND	OSERV	OSTAT
IO & IOC	OPUS2	GRIND READBP READUP	CREAD CHECK	CROPIN MGRIN GETMET FKSL	SETLAY BRAKS BLKDAT	SOILAD	RFXS	CAPACY	CNRO	HAWOOD UPDATE RGATE	PESTMV CHMTRF FLASH			SPOND	FROQ	SUMST ANSTAT HYFILE SLFILE
KEEP	OPUS2	GRIND READBP	CREAD													
LABILE		GRIND	CREAD	PRELIM	SETLAY BLKDAT	SOILMV SOILAD				HAWOOD	CHMTRF UPTAKE FLASH	NCYCL				SUMST SLFILE
LIMITS	OPUS2	GRIND READBP	CREAD	GETMET												ANSTAT
LOCAL			CREAD				RFXS SURF			RGATE						
MGMT		GRIND CFACT	CREAD MGRIN		BLKDAT					HAWOOD RGATE UPDATE RECROP	FLASH					
MGTH			MGRIN							HAWOOD						
NOPTS	OPUS2	GRIND CFACT	CREAD	PRELIM		SOILMV SOILAD	RFXS		CNRO	HAWOOD RGATE UPDATE ROOTDK RECROP	CHMTRF UPTAKE PESTMV PESTDK TPFUNC			SPOND	WFUNC	SUMST HYFILE SLFILE
NUTRIN		GRIND	CREAD	PRELIM	SETLAY					HAWOOD UPDATE ROOTDK RECROP	UPTAKE FLASH	NCYCL SAVARP				
PARAM				PRELIM								CYCLE DECOMP NCYCL				

OPUS FILES (Continued)

COMMON BLOCK	OMAIN	OGRIND	OREAD*	IOAUX	OPRELM	OSOIL	OHYDR	OSED	ODAILY	OCROP	OCHEM	ONUTRS	OWTHR	OPOND	OSERV	OSTAT
PARAM												PARTIT SETPAR SIMSOM				
PESTAB			CREAD			SOILAD				HAWOOD	CHMTRF PESTMV PESTDK					CHEMTAB ANSTAT
PESTI		GRIND	CREAD	MGRIN		SOILAD				HAWOOD UPDATE RGATE ROOTDK	CHMTRF PESTMV PESTDK					SUMST HYFILE SLFILE CHEMTAB
PLOTS				PRELIM								CULTIV CYCLE DECOMP EROSN METRCM NCYCL PARTIT SAVARP SIMSOM FLOWUP				
PONDC			CREAD											SPOND QOD DOV VOD		
RAINUP		READBP READUP														
RMETR	OPUS2	GRIND DTDF	CREAD	GETMET									TRGEN THERAD RFGN WGENR FGENR			SUMST ANSTAT

OPUS FILES (Continued)

COMMON BLOCK	OMAIN	OGRIND	OREAD*	IOAUX	OPRELM	OSOIL	OHYDR	OSED	ODAILY	OCROP	OCHEM	ONUTRS	OWTHR	OPOND	OSERV	OSTAT
SED	OPUS2	GRIND	CREAD		PRTCMP PORDER		RFXS SURF	SEDCOM CAPACY	CNRO					SPOND	ENRCMP RILLGM	SUMST
SEDCH		GRIND						SEDCOM CAPACY								
SNMLT							RXFS						TIMELT			
SOIL	OPUS2	GRIND CFACT	CREAD	CROPIN PRELIM	SETLAY BRAKS	SOLTM DRAINF SOILMV SOILAD SLOPE	RFXS		CNRO	HAWOOD UPDATE ROOTDK	CHMTRF UPTAKE FLASH PESTDK	NCYCL	SNOWF EVAP			SUMST SLFILE CHEMTAB
STATE	OPUS2	GRIND READBP READUP CFACT DTDF	CREAD	PRELIM MGRIN	SETLAY	SOILMV DRAINF SOILAD	RFXS SURF	SEDCOM	CNRO	HAWOOD RGATE UPDATE LEAVES ROOTDK RECROP	CHEMFL CHMTRF UPTAKE FLASH PESTMV PESTDK	SAVARP	TRGEN EVAP RICHET SNOWF		FMANN	SUMST ANSTAT SLFILE
STATS	OPUS2	GRIND	CREAD		BLKDAT					HAWOOD RGATE	FLASH PESTDK					SUMST ANSTAT
STRESS										UPDATE						SUMST ANSTAT
TONCYC			CREAD	PRELIM	SETLAY		RFXS			HAWOOD UPDATE ROOTDK	FLASH	DECOMP PARTIT SIMSOM			ENRCMP	
TRANSF											RKSORB FONE GONE					

*Note: OREAD is actually composed of two files, OREADA and OREADB.

Opus: An Integrated Simulation Model for Transport of Nonpoint-source Pollutants at the Field Scale. Volume II, User Manual

Errata et addenda

May, 1999

Page 17. Record A02 is revised to accommodate 4-digit years, as indicated by the paste-on change on this page. An example is shown in the README.DOC file, and the sample parameter file furnished on the distribution disk.

Page 19. Flag IFOUT, record A03, has an additional value of 2, which calls for a line on the main output for every day of simulation, regardless of a precipitation event.

Page 20. An additional (eighth) parameter has been added to record A04, called IFDIAG, read in positions 57 thru 63. This flag, if positive, allows diagnostic printout in certain cases where iterations are extended or small balance errors are detected.

Page 21. Middle of page: There are two additional irrigation types for Flag IFIRR, record A04:

IFIRR=4 indicates basin/flood irrigation type, with no simulation of surface advance rate, but otherwise like IFIRR=3.

IFIRR=5 is like IFIRR=3 except that the user is allowed to specify up to 12 specific dates of application on records immediately following record E17. The number of dates is given as before by parameter NIRD. The actual date and amount records are preceded by a template line, and that line and one such record example are as follows:

```
    MO  DA          AMOUNT
     7  05           118.0                                  EIR
```

The format of line 'EIR' is free, but it must end with the characters 'EIR'.

Page 27. Record C01. Opus has been modified to allow some flexibility in the number of numerical layers into which the soil profile is divided. This can be indicated by a second parameter on record C01, in positions 8 thru 14, called ILAY. ILAY may be from 20 thru 49. Large values of ILAY will result in more layers, more soil water simulation precision, and more computational time. Default ILAY is 20, as before.

Record C02. Parameter PSILT has been eliminated, since silt plus sand plus clay must equal to 1.0, and replaced. The new parameter in this position is PARA, and it has several optional uses which are described in the README.DOC file accompanying the program.

Page 29. Line 12: replace '1-n' with 'n*m'. Note that van Genuchten's 'm' is usually defined as 1 - 1/n.

Page 31. Record C03. Parameter OMP has been replaced, since in most all cases organic P should be in equilibrium with organic N and C. The parameter replacing it is CURV, the value of which is discussed in the README.DOC file.

Record D02. An additional crop type has been added, IPER = 5, which represents perennial 'tropical' vegetation. This plant type should only be specified in warm climates where there is continuous vegetation. This generic crop type should not be planted, since it is assumed to be active, does not annually defoliate, and responds only to N, water, and temperature stresses.

Page 36. There are two additional optional plant parameters on Record D03, in the last two 7-character positions. They are described also in the README file. The first is PST(J), which is an index from 0 to 1.0, representing the value of *relative* plant age in growth degree-days ("DD") (measured as T - TGBM) at which the plant begins to divert material into fruit formation. Formerly this was fixed at 0.7, which remains the default. Values from 0.1 to 0.7 are accepted.

The second additional optional plant parameter is HPC(J), which represents the absolute value of the soil pressure head above which (greater stress than which) the plant root cannot take all the water it needs. This value was formerly fixed at 2000mm, which remains the default when a value less than 500 is entered here.

Page 40. Under IDTIL(J), change IFOUT=2 to IFOUT=1.

Page 45. Record E06. There are two additional optional pesticide parameters added in 7-character positions 4 and 5 (positions 22-28 and 29-35). The first new parameter is ZDGR, and is the ratio of degradation rate below the root zone to the rate within the root zone for that pesticide. The previous value used by Opus was 0.01, but that is apparently far too small, and the default now used is 0.1.

The second new optional pesticide parameter is called PUPTK. It describes plant uptake of a specific pesticide through its roots, and is a relative value from 0 to 1. PUPTK=0 [the default] means that the plants will not take the pesticide in through the roots, while PUPTK=1.0 means that plant will uptake the pesticide in exactly the proportion that the pesticide is found dissolved in the soil water at each depth in the soil.

Page 50. Record E17, parameter IRRDY(Y). Remove the phrase 'for ditch supply type irrigation' (this applies to more than this option.

Page 51. Record E18: An additional feature has been added to version 2.1G (May 1999), allowing optional annual change in water table depth. This will not be important when the water table is so low as to have little influence on the soil pressure head at the bottom of the root zone. One can now simulate a water table which fluctuates during the year above and below the mean value given as DWTB on line B01. This option is available only when there are no draintiles (IFDRAN=0), and the minimum DEPTH of water table [DWTB - amplitude] still must be 100mm greater than the maximum root depth. For this purpose 3 new variables are read on line E18, each occupying 7 character spaces:

The excursion amount (amplitude) which is the maximum either added to or subtracted from DWTB is called WTAMPL, in either feet or meters, according to the units chosen.

The julian day (1 to 366) on which the minimum DEPTH to water table (maximum elevation) occurs is called ITBMIN. (usually in early spring)

The julian day (1 to 366) on which the maximum DEPTH to water table (minimum elevation) occurs is called ITBMX.

IMPORTANT: The difference in days from ITBMIN to ITBMX must be greater than 180 and less than 325. The julian day for ITBMIN can be in the previous year, or ITBMX can be in the next year, but the spread in days must be within the limits stated above. These new parameters are ignored when WTAMPL is less than 1 mm. or when draintiles are simulated.

Page 66. NUN(KL). The use of 'L' in this description refers to an index for each element: 1 for planes, 2 for the first channel, and 3 for a second receiving channel IF used.

Page 79. Record I01, IYR is no longer limited to 2 digits, although a 2-digit year description may be used. But when a 4 digit year is used, the last two digits must be in the same position (7 and 8).

Page 84. Figure 22 showing a sample actual data file was in error and a paste-over is supplied with the correct format.

Page 85. Record J03, parameter IRLDA. This date record (year plus gregorian day) may now use a 4-digit year, with 7 rather than 5 digits, and its format will be (I8): [yyyyddd].

Page 89. Second paragraph: the addition of IFOUT=2 option has been described above.

Page 97. **Running Opus**, line 1: Opus is now run under windows95. A DOS or batch version is available on request. In addition, it can be run in demonstration mode, in which the soil water profile and optionally the solute profile of NO_3 and NH_4, or of a selected pesticide is displayed while stepping through the simulation at a uniform rate of about 3 days per second. In addition, the root depth of the current crop is displayed symbolically. This option [found in the Output Files Dialog] should not be used for long simulations, but is instructive for assessing the fate of a chemical of interest.

Appendix C: The additional optional parameters described above will add or change some of the parameter lines shown here.

Appendix D: Please note before copying for use, that the values in **Part 1** of this appendix are **metric**, but may be converted to English units if desired by using the formulas in Table 14. The parameter values in **Part 2** are in **English units**.