Chapter 16: Modules and Variables of 2DSOIL

Dennis Timlin and Yakov Pachepsky

The modules of 2DSOIL have been designed to be as independent as possible, and only variables (global public variables) needed by two or more modules are shared. The global public variables are stored in a FORTRAN COMMON block that is inserted into each process module via the file '**public.ins**'. The division of information into public and private components is one of the important advantages of modular programming and makes the modules of 2DSOIL completely autonomous. There are no subroutines that are shared or otherwise called by more than one module even though two or more modules may use similar algorithms. This has been done to allow a user to substitute their own modules with a minimum of changes to their module. Because most variables are private (i.e., not in common statements shared among modules), there is less chance for conflicts among variable names. The disadvantage is that this structure may result in duplication of code and similar variable names in two or more modules, and longer code.

16.1 Structure of the code.

2DSOIL consists of a main program and a number of subroutines. The subroutines are distributed among a number of source files. A list of source files in the code and routines called is shown in Table 16.1. Although there are a large number of subroutines available, any particular application of 2DSOIL will, generally, only require a subset of these subroutines. If a user wishes to build an application that simulates only water flow, for example, modules for chemistry, solute transport, heat flow, etc. are not necessary. A complete description for building an application was given in chapter 15.

- Subroutine **Initialize** zeroes all public variables.
- Subroutine **Get_Grid_and_Boundary** reads data on grid and boundary parameters and calculates areas of elements.

- Subroutine **Synchronizer** reads the time stepping parameters including the start and stop times, and finds the next time step. It uses data on the next input and output times, information on iteration convergence, and values of time steps produced by the soil transport process modules.
- Subroutine **SetSurface** produces potential fluxes of water, solutes, heat, and gases at the soil-atmosphere boundary. The **SetSurface** in 'SetSurf01.for' source file reads boundary values from the data file. The **SetSurface** in the '*SetSurf02.for*' source file calculates boundary values from daily meteorological data sets.
- Subroutine **Fill** sends boundary data sets to the prescribed node. Subroutine **SetTDB** sets potential boundary fluxes and/or boundary values of state variables for soil transport processes.
- Subroutine **WaterMover** simulates water movement in soil. Subroutine **Veloc** calculates water fluxes.
- Subroutine **SetMat** produces parameters of water transport. Source file '*SetMat01.for*' contains subroutines for closed-form approximation of soil hydraulic properties using the formula of van Genuchten (1980). The functions **FK, FC, FQ, FH** calculate unsaturated hydraulic conductivity, specific water capacity, moisture content, and hydraulic head, respectively. Source file '*SetMat02.for*' contains subroutines for piece-wise polynomial approximation of soil hydraulic functions.
- Subroutine **HydSub** approximates moisture release curves and hydraulic conductivity curves for soil layers by piece-wise smooth polynomials. For a given suction value and soil layer **HydSub** calculates moisture content, specific water capacity, and hydraulic conductivity. Subroutine **prep** calculates coefficients of cubic polynomials from data on measured pairs of moisture content-soil suction and hydraulic conductivity-soil suction.
- Subroutine **SLNQ** solves a system of linear equations. Subroutine **qeq** solves a cubic equation for moisture contents. Functions **Curt** and **Akwrt** calculate cubic and square roots of complex variables, respectively.

- Subroutine **SoilNitrogen** calculates nitrogen transformations in soil. Subroutine **SetAbio** calculates the correction factors for the various rate constants as a function of soil temperature and soil water content.
- Subroutine **SoluteUptake** calculates active uptake of a solute, e.g.,nitrogen (solute number 1) with water.
- Subroutine **SoluteMover** calculates redistribution of solute concentrations during water movement. Subroutine **Disper** gives values of solute transport parameters, and subroutine **WeFact** calculates weighting factors for upstream weighting of velocities. Function **Tau** gives tortuosity factor values.
- Subroutine **HeatMover** calculates soil temperature changes due to heat movement. Subroutine **Thermal** gives heat transport parameters.
- Subroutine **GasMover** calculates gas contents in soil air. Subroutine **DiffCoef** gives values of gas diffusion coefficients and air-filled porosity.
- Subroutine **RootWaterUptake** simulates root water uptake and root growth. The **RootWaterUptake** module in the source file '*WatUpt01.for*' calculates the functional balance between shoot and root which will satisfy transpiration demand as long as carbon is available for root growth. Subroutine **SORT** orders soil cells in descending order with respect to favorability for root growth. The **RootWaterUptake** module in the source file '*WatUpt02.for*' uses a static root distribution and calculates root water uptake as a function of soil moisture potential and transpiration demand.
- Subroutine **ShootImitator** produces shoot variables that are used by the **RootWaterUptake** subroutine. The **ShootImitator** in the source file '*Shootim1.for*' calculates carbon assimilation as a function of radiation and gives values of carbon available for roots to grow and estimates the shadowing of soil by plants. This module does not consider nitrogen stress. It must be used with the **RootWaterUptake** from the source file '*WatUpt01.for*'. The subroutine **ShootImitator** in the source file '*ShootIm2.for*' is similar to the one in '*Shootim1.for*' but uses nitrogen stress. It must be used with the same subroutines mentioned above as well as the **SoluteMover**, **SoluteUptake**, **SoilNitrogen**, and **HeatMover**. The **ShootImitator** in the source file

'*ShootIm3.for*' only estimates shadowing of soil by plants, and it must be used with the **RootWaterUptake** in the source file '*WatUpt02.for*'.

- Subroutine **MacrChem** calculates equilibrium distributions of ions between soil phases. Subroutine **Actic** prepares auxiliary variables for calculation of solution composition and ion pair contents. Subroutine **Backs** solves a system of linear equations. **Block Data** contains constant parameters of the chemical equilibrium model. Subroutines **HEQ3** and **HEQ4** solve cubic and biquadratic equations for the hydrogen concentration, respectively. Subroutine **Inisl** calculates initial estimates for the distribution of given total amounts of ions between soil phases. Subroutine **Ion** calculates contents of species in the solution. Subroutine **Libra** calculates chemical equilibrium for one node. Subroutine **Nonlin** solves a system of nonlinear equations using a modified Newton's method. Subroutine **Res** calculates residuals of nonlinear equations. Subroutine **Resolv** prepares and controls the process of solution of the nonlinear system of equations describing equilibrium in the soil chemical system. Function **Rwndr** generates random numbers. Subroutine **WSMPLX** solves a system of nonlinear equations using a weighted simplex method. Subroutine **Xform** updates, if necessary, the weight coefficients for amounts of non-associated ions.
- Subroutine **Output** prints arrays of grid variables to disk files at prescribed simulated times. Subroutines **ArrElemOut** and **ArrNodOut** print variables associated with grid elements and with grid nodes, respectively.
- Subroutine **ErrMes** prints error messages to the screen and to disk file.

Table 16.2. Subroutines in 2DSOIL code

Source file	Modules	Submodules included and/or called
2dmain.for	Initialize Get_Objects_and_Timeset Get_Grid_and_Boundary Synchronizer SetSurface SetTDB SoluteMover WaterMover HeatMover GasMover RootWaterUptake SoilNDen SoluteUptake ShootImitator Management Output ScreenOutput MacroChem	
errmes.for	ErrMes	
gasmov.for	GasMover	DiffCoeff
grid_bnd.for	Get_Grid_and_Boundary	
heatmov.for	HeatMover	Thermal
init.for	Initialize	
macrchem.for	MacroChem	Libra, RESOL, Xform, ION, SORPT, HEQ3, HEQ4,NONLIN, Backs, Wsmplx, RWRND
output.for	Output	ArrElemOut , ArrNodOut
setmat01.for	SetMat	FK, FC, FQ, FH
setmat02.for	SetMat	HYDSUB, qeq, curt, Akwrt, prep, SLNQ
setsur01.for	SetSurface	Fill
setsur02.for	SetSurface	
settdb.for	SetTDB	
shootim1.for	ShootImitator	
shootim2.for	ShootImitator	
shootim3.for	ShootImitator	
soilnden.for	SoilNitrogen	SetAbio

Table 16.2. Subroutines in 2DSOIL code

Source file	Modules	Submodules included and/or called
solmov.for	SoluteMover	Disper, WeFact, Tau
solupt.for	SoluteUptake	
syncron.for	Synchronizer	
watmov.for	WaterMover	Veloc, SetMat
watupt01.for	RootWaterUptake	SORT
watupt02.for	RootWaterUptake	

16.2 Notes on compiling 2DSOIL with different arrangements of subroutines.

This setup of 2DSOIL is constructed so that the structure and content of 2DMAIN.FOR will stay the same regardless or which components are compiled. All the calls to the main 2DSOIL subroutines are retained in 2DMAIN.FOR. If a component (subroutine) such as **HeatMover** is not used in a particular variation of 2DSOIL, the call to **HeatMover** still remains in the 2DMAIN.FOR file. A call to a dummy routine is placed in an additional FORTRAN file and the **HeatMover** code (**heatmov.for**)is not linked with the rest of the code. For instance, each example contains a FORTRAN file with the example's name i.e., Ex14-3.FOR. This file contains calls to all the subroutines listed in 2DSOIL.FOR but not used in an application. The file Ex14-4.FOR will look like this:

```
C   These are dummy subroutines to replace any modules
C   not used by a particular model application
c   use this module for example 14-3

       Subroutine GasMover()
       return
       end

       Subroutine GasUptake()
       return
       end

       Subroutine SoilNitrogen()
       return
```

```
end

Subroutine SoluteUptake()
return
end

Subroutine ScreenOutput()
return
end


Subroutine Mngm()
return
end

Subroutine ShootImitator
return
end

Subroutine RootWaterUptake
return
end

Subroutine SetSurface
return
end

Subroutine HeatMover
return
end
```

Calls to subroutines that contain components that are not used in a particular application of 2DSOIL are done in one file. These files are given as Ex14-1.FOR etc. When dummy calls to unused components are used like this, the 2DMAIN.FOR file does not have to be modified for a particular variation of 2DSOIL. The file with the dummy calls e.g., Ex14-3.FOR, is compiled and linked with all the other FORTRAN files. The distribution disk contains a FORTRAN file for each example that provides stubs for subroutines of components that are not used. Table 16.2 lists the files compiled and linked for each of the examples. A make file '*.mk' and a link file '*.lnk' for each example are available in the distribution disk. These files are applicable to the Salford Fortran compiler. If you use another compiler the syntax will probably change.

Table 16.2 list of files to be linked for each example.

Example 1	Example 2	Example 3	Example 4	Example 5
2dmain	2dmain	2dmain	2dmain	2dmain
errmes	errmes	errmes	errmes	errmes
Ex14-1	Ex14-2	Ex14-3	Ex14-4	Ex14-5
grid_bnd	grid_bnd	grid_bnd	grid_bnd	grid_bnd
init	heatmov	init	init	heatmov
output	init	macrchem	mngmb	init
setmat01	output	output	output	mngmb
setsur02	setmat01	setmat01	setmat01	n_massbl
settdb	setsur02	settdb	setsur01	output
shootim3	settdb	solmov	settdb	setmat01
synchron	shootim2	synchron	shootim2	setsur02
watmov	synchron	watmov	solmov	settdb
watupt01	watmov		synchron	shootim1
	watupt01		watmov	soilnden
			watupt01	solmov
				solupt
				synchron
				watmov
				watupt01

16.3 Variables of 2DSOIL.03.

All important variables are listed in the Table 16.3. There is also a complete reference of variables, available in a separate file, '*RefVar.lst*', which shows where a variable is used and altered in a module. The beginning of this reference is in Table 16.4 for illustrative purposes.

Table 16.3. List of significant variables of 2DSOIL

A(MBAND,NumNPD)	Coefficient matrix of the global system of equations of the finite element metho d.
ADRL(NumEl)	Actual change in root length in soil cell for past period, cm.
ADWR(NumEl)	Actual rate of increase in root dry weight in soil cell, g hr-1.
ALPM	Potential relative old root growth rate, day-1
ALPY	Same as above for the young roots
AMMON_N	Ammonia Nitrogen kg ha-1
AS	See listing of the SLNQ subroutine.
AS1	See listing of the SLNQ subroutine.
ATEMP	Factor for changing temperature units.
ATRANS	Atmospheric transmission coefficient.
AVAIL	Ammonium available for immobilization
AVP	Actual water vapor pressure for day (assumed constant), kPa.
AWR(NumEl)	Actual increase in root weight in soil cells for past period, g.
AWUP(NumEl)	Rate of water extraction from soil cells by roots, g hr-1.
Ac(NumNP)	Nodal values of the coefficient at time derivative term
Acc	See listing of the WSMPLX routine.
Aleng	Length of the triangular element side
Alfa	Parameter in the soil water retention function (see section 6.3). Activity coefficient of univalent nonassociated ions after previous iteration.
B(NumNPD)	Coefficient vector.
BB	See listing of the SLNQ subroutine.
BCH	New value of soil carbon g cm-3 soil
BCL	new value of carbon content in the litter g cm-3 soil
BCM	new value of carbon content in the organic fertilizer g cm-3 soil
BEERS	Beer's law correction for light passing through the canopy.
BIR	Factor for changing rainfall intensity units.
BNH	New value of nitrogen in the organic matter g cm-3 soil
BNH4	New value of ammonium-N in the soil g cm-3 soil
BNL	New value of nitrogen in the litter g cm-3 soil
BNM	New value of nitrogen in the manure g cm-3 soil
BNNH4	New value of ammonium-N in the soil g cm-3 soil
BNO3	New value of nitrate-N in the soil g cm-3 soil
BSOLAR	Factor for changing solar radiation units.
BTEMP	Factor for changing temperature units.
BTPL	Lowest value of leaf turgor pressure reached so far today, bar.
BWIND	Factor for changing wind units.
BlkDn	Current nodal value of the soil bulk density
BulkDn(NumNP)	Array of nodal values of the soil bulk density, g cm-3.
CEC	Canopy extinction coefficient. Also: Soil cation exchange capacity, eq per L of the soil solution.

Table 16.3. List of significant variables of 2DSOIL

CLDFAC	Cloud cover factor for this latitude.
CLIMAT	Array of climatic variables for the next day.
CLOUD	Proportion of sky covered with cloud (1 = full cover).
CM	Current value of carbon in the manure g cm-3
CO3	Concentration of non-assosiated bicarbonate ions, mol L-1.
COND(NumEl)	Unsaturated hydraulic conductivity averaged over elements, cm day-1.
CONVR	Amount of carbon needed to make unit root dry weight, g g-1.
COVER	Proportion of soil covered by crop.
CPREC	Concentrations of solutes in the rain/irrigation water, g cm-3.
CS	Michaelis-Menton constant of denitrification g cm-3 soil
CXT(NumEl)	Oxygen concentrations in soil air (volume fraction of air).
Ca	Concentration of nonassociated calcium ions, mol L-1
CaCO3	Concentration of the CaCO30 ion pairs, mol L-1
CaHCO3	Same as above for the CaHCO3+ ion pairs.
CaOH	Concentration of the CaOH+ ion pairs, mol L-1.
CaSO4	Concentration of the CaSO40 ion pairs, mol L-1.
Cal	Nodal value of the calcite content. g per g of dry soil.
Calcite	Calcite content in mol of solid salt per L of the solution.
CalciteNod	Solid calcite content, g per g dry soil
Cap(NumNP)	Nodal values of the soil water hydraulic capacity, cm-1.
CapE	Soil water hydraulic capacity of the element, cm-1.
CapTab(NTab,NMat)	Tabulated values of the soil water hydraulic capacity, cm-1
ChName	Constant strings in the names of output files
Cl	Concentration of nonassociated cloride ions, mol L-1.
CodeG	Codes of boundary condition for the gas movement
CodeS	Same as above for the solute movement
CodeT	Same as above for the heat movement
CodeW	Same as above fot the water movement
Coef	See listing of the NONLIN subroutine.
Con(NumNP)	Nodal values of the hydraulic conductivity, cm day-1.
ConAxx(NumEl)	Nodal values of the 'xx' component of the anisotropy tensor.
ConAxz(NumEl)	Same as above for the 'xz' component
ConAzz(NumEl)	Same as above for the 'zz' component
ConE	Same as above
ConSat(NMat)	hydraulic conductivities of soil layers, cm day-1.
ConTab(NTab,NMat)	Tabulated soil hydraulic conductivity, cm day-1.
Conc(NumNP, NumS)	Nodal values of the concentrations, g cm-3.
ConcCa	Nodal value of calcium ions concentration in g L-1.
ConcCl	Same as above for cloride ions.
ConcMg	Same as above for magnesium ions.
ConcNa	Same as above for sodium ions.
ConcSO4	Same as above for sulphate ions.

Table 16.3. List of significant variables of 2DSOIL

ConcUnitCa	Factor to convert Ca2+ concentration units to mol L-1.
ConcUnitCl	Same as above for the Cl- concentration.
ConcUnitMg	Same as above for the Mg2+ concentration.
ConcUnitNa	Same as above for the Na+ concentration.
ConcUnitSO4	Same as above for the SO42- concentration.
CourMaX	Maximum allowed Curant number.
Courant	Maximum local Courant number.
Cwat	Heat capacity of water, J g-1
DAWN	Time of dawn, hr.
DAYLNG	Daylength, hr.
DDIF	Amount by which daylength exceeds an even number of hours, hr.
DEC	Solar declination, radians (first calculated in degrees).
DEGRAD	Degree to radian conversion factor (/180).
DEL(24)	Hourly slopes of saturation vapor pressure curve at air temperature, kPa oC-1.
DENIT(i)	amount of N denitrified in node I g cm-3
DENITR	cumulative amount of N denitrified in profile kg ha-1
DIFFIN	Proportion of diffuse radiation intercepted by "solid" rows.
DIFINT(20)	Proportion of sky obscured by "solid" rows from a given point at soil level.
DIFWAT(24)	Hourly proportions of total radiation that is diffuse.
DIRINT(24)	Hourly proportions of direct radiation intercepted by rows of plants assuming they are opaque cylinders.
DPSI02	Change in leaf water potential corresponding to a change of 2 bar in leaf turgor pressure, bar.
DRL(NumEl)	Potential changes in root length in elements for past period, cm
DS(NumNP)	Vector {D} in the global equation for water flow, cm2 day-1 or cm3 day-1 (see Eq. (6.7)); also used for the diagonal of the coefficient matrix [Q] in the global matrix equation for solute, heat and gas transport, cm2 or cm3 (see Eq. (7.9)).
DTHH	highest volumetric water content for which the N process is otptimal
DTHL	lowest volumetric water content for which the process is optimal
DTOT	Total nitrogen during a time step g cm-3
DUSK	Time of dusk, hr.
Dair(NumG)	Diffusion coefficients of gases in free air, cm2 day-1.
DerMax	See listing of the NONLIN subroutine
Diff(NumNP)	Nodal values of gas diffusion coefficients, cm2 day-1.
Dispxx(NumNP)	Nodal values of the 'xx' component of the solute dispersion tensor, cm2 day-1.
Dispxz(NumNP)	Same as above for the 'xz' component.
Dispzz(NumNP)	Same as above for the 'zz' component.
Dlng(NMat,NumSol)	Longitudinal dispersivity of solutes, cm.
Dmol(NumSol)	Ionic or moleqular diffusion coefficients of solutes in free water, cm2 day-1.
Dpom	Factor in the correction terms for eliminating of the numerical dispersion, day-1.
DtRain	Duration of rain, day.

Table 16.3. List of significant variables of 2DSOIL

Dtrn(NMat, NumSol)	Transversal dispersivities of solutes, cm.
E(3,3)	Element contributions to the global matrix A for water flow, cm-2
ED	Relative effect of moisture on denitrification
ELCAI	Effective leaf area per unit ground area covered by crop canopy allowing for the fact that light at a low angle traverses more leaf layers to the soil.
ENOUGH	if .true. then there is enough mineral N for immobilization
EO	Potential transpiration (=leaf water evaporation) rate for a canopy, cm3 per cm of row per day
EOMult	Multipliyer depending on the plant position (=1 if the plant is not on the border of the soil slab, =0 if it is on the border).
EOR	Potential transpiration rate per half cm of row (=EORSCF at night) (g hr-1).
EORSCF	EOR*SCF=potential transpiration rate from leaves per half cm of row as limited by stomatal closure, g day-1.
EPO	Potential transpiration rate from the crop, g m-2 hr-1.
ERAIN	Factor for changing units of the amount of raifall.
ESO	Potential evaporation rate from soil surface, g m-2 hr-1.
ET	(in soilNden) Correction factor for temperature
EW	Correction factor for water for immobilization and mineralization of N
Ec	Gas diffision coefficient in an element, cm2 day-1.
Ec1	The 'xx' component of the dispersion, diffusion or thermal conductivity averaged over an element, cm2 day-1.
Ec3	Same as above for the 'zz' component.
Eps5	Tolerable residual of the cubic equation for the hydrogen concentration
EpsD	Tolerable relative error for ion mass balance.
Epslon	Absolute change in the nodal pressure head between two successive iterations, cm
ExCa	Nodal content of the exhangeable calcium in g g-1.
ExMg	Nodal content of the exhangeable magnesium in g g-1
ExNa	Same as above for the sodium.
ExchCa(NumNP)	Array of exhangeable calcium nodal contents, g g-1.
ExchMg	Same as above for the magnesium.
ExchNa	Same as above for the sodium.
ExchUnitCa	Factor for changing of exchangeable Ca2+ content units
ExchUnitMg	Same as above for the exchangeable Mg2+ content.
ExchUnitNa	Same as above for the exchangeable Na+ content.
Explic	Logical variable indicating whether an explicit or implicit scheme was used for solving the water flow equation.
F(NumNP)	Diagonal of the coefficient matrix [F] in the global matrix equation for water flow, cm2 or cm3.
FA	Fraction of the mineral N available for immobilization

Table 16.3. List of significant variables of 2DSOIL

FCO3	ame as above for carbonate ions.
FCSH	Coefficient of convective heat transfer for bare soil, J cm-2 d-1 oC-1)
FH	Humification fraction, the fraction of carbon that is available to become organic matter
FHCO3	Concentration of bicarbonate ions in the solution, mol L-1
FOH	Same as above for hydroxil ions.
FSO4	Concentration of sulphate ions in the solution, mol L-1
Fc(NumNP)	Components of the vector {f} in the solute, heat and gas transport equations (see Eq. (7.9)), g cm2 day-1.
FcE	Nodal components of the Fc averaged over an element, g cm2 day-1.
Fca	Concentration of the calcium ions in the solution, mol L-1.
Fcl	Concentration of the cloride ions in the solution, mol L-1.
Fmg	Same as above for magnesium ions.
Fna	Same as above for sodium ions.
FracClay(NMat)	Mass fraction of clay, %
FracOM(NMat)	Mass fraction of organic matter, %
FracSind(NMatN)	Mass fraction of sand+silt, %
IDAWN	Number of calculation period during which dawn occurs.
IDN	Number of calculation period prior to IDUSK.
IDUSK	Number of calculation period during which dusk occurs.
IFUR	Switch that indicates presence or absence of the furrow irrigation.
IHPERD	IPERD/2.
IJ	Maximum number of nodes on any transverse line.
IPERD	Number of calculation periods in the photoperiod. The arrays are currently set up for a maximum of IPERD=24.
IRAV	Average rain intensity, cm day-1.
IS1	Switch to show presence of calcite in solid phase.
IS2	Same as above for gypsum
IS3	Same as above for magnesite.
ISCH	Code of usage for the HYDSUB subroutine (see listing).
ISOL	Code that shows whether solute cocentrations in raifall are to be read
ITIME	Number of the current hour counting from midnight.
IUP	Number of hours following IDAWN.
Isc	Current code of the present solid salts set: Isc = 4*Is3+2*Is2+Is1.
ItCrit	Logical variable indicating whether or not convergence was achieved.
Iter	Number of iterations.
Itmax	See listing of NONLIN.
Itry	Number of trials to improve initial estimates for NLE solver.
Ivar	.true., if the variable is included in the system of nonlinear equations.
JDAY	Day of year.
JDFRST	Day of year on which model run starts.

Table 16.3. List of significant variables of 2DSOIL

JDLAST	Day of year on which model run stops.
KAT	Code to show if axisymmetrical or planar movement is to be simulated.
KD	denitrification rate adjusted for temperature and soil moisture, day-1
KD0	Potential denitrification rate, day-1
KH	mineralization rate constant adjusted for temperature and soil moisture, day-1
KH0	Potential mineralization rate constant, day-1
KL	The rate constant for the decomposition of plant residues, day-1
KM	The rate constant for decomposition of organic fertilizer corrected for soil water content and temperature, day-1
KM0	the potential rate constant for decomposition of organic fertilizers, day-1
KN	the nitrification rate corrected for water and temperature, day-1
KN0	the potential nitrification rate day-1
KX(NumEl,4)	Global nodal numbers of element corner nodes.
KXB(NumBP)	Global nodal numbers of sequentially numbered boundary nodes .
Ks	Saturated hydraulic conductivity, cm2 day-1.
LAMDAC	Albedo of crop.
LAMDAS	Albedo of soil.
LAREAT	Total leaf area per plant, cm2.
LATUDE	Latitude, degrees.
LCAI	Leaf area per unit ground area covered by crop canopy.
LINE	String to accomodated data prior to printing.
LITTER_N	Total amount of N in the litter, kg ha-1
LOCATE	See listing of the SORT subroutine.
Length	Width of soil surface associated with transpiration, cm or cm2.
Level	Number of the assembling of A and B matrices during time step.
List	Array of numbers of variables which are included in the system of nonlinear equations
ListE(NumEl)	List of elements that form the reduced flow region for the second and subsequent iterations in water movement calculations.
ListNE(NumNP)	Number of subelements adjacent to a particular node.
MANURE_N	Total amount of N in manure, kg ha-1
MARRAY	See listing of the SORT subroutine.
MDAY	Day of year for line of weather data file just read.
MECHR	Soil mechanical resistance to root growth, bar.
MIN_N	Total amount of in in the form of nitrate, kg ha-1
MLAY	Maximum number of soil layers.
MREL	Maximum number of measured water retention values.
MSW1	Switch to indicate if daily wet bulb temperatures are available (=1 if they are).
MSW2	Switch to indicate if daily wind is available (=1 if it is).
MSW3	Switch to indicate if daily rain intensities are available (=1 if yes)

Table 16.3. List of significant variables of 2DSOIL

MSW4	Switch to indicate if daily solute concentrations in the rain water are available (=1 if yes)
MSW5	Switch to indicate if flooding irrigation will be applied (=1 if yes).
Magnesite	Magnesite content in mol of solid salt per L of the solution.
MatNumE(NumEl)	Numbers of soil layers or horizons where the elemnts are.
MatNumN(NumNP)	Numbers of soil layers or horizons where the nodes are.
MaxIt	Maximum number of iterations allowed during any time step or during one NLE solver call.
Mband	Bandwidth (half-bandwidth) of the symmetric (asymmetric) matrix A.
MbandA	Bandwidth of Matrix A for the second and subsequent iterations of water movement calculations (reduced flow region).
MbandD	Maximum permitted bandwidth of matrix A - maximum allowed difference between numbers of corner nodes for any two elements having at least one common node.
Mg	Concentration of nonassociated magnesium ions, mol L-1.
MgCO3	Concentration of MgCO30 ion pairs, mol L-1.
MgHCO3	Concentration of MgHCO3+ ion pairs, mol L-1.
MgOH	Concentration of MgOH+ ion pairs, mol L-1.
MgSO4	Concentration of MgSO40 ion pairs, mol L-1.
ModNum	ID number of module
NARRAY	See listing of the SORT subroutine.
NCD	Number of climatic varibles available for each day.
NH(i)	Nitrogen in humus g cm-3
NL(i)	Nitrogen in Litter g cm-3
NM(i)	Nitrogen in organic fertilizer, g cm-3
NN	Number of nodes in the reduced flow region for the second and subsequent iterations.
NNH4(i)	Nitrogen in the form of ammonium, g cm-3
NNO3_SOL	Nitrate in solution, g cm-3
NP(NSeep,NumSP)	Sequential numbers of nodes on the seepage faces
NQ	ratio of mineral nitrate to the mineral ammonium characteristic for a particular soil
NRATIO	Nitrogen supply/demand ratio for vegetative parts.
NSP(NSeep)	Numbers of nodes on seepage faces.
NUS	Number of corner nodes of a particular element
Na	Concentration of nonassociated sodium ions, mol L-1.
NaCO3	Concentration of NaCO3- ion pairs, mol L-1.
NaCl	Concentration of NaCl0 ion pairs, mol L-1.
NaHCO3	Concentration of NaHCO30 ion pairs, mol L-1.
NaSO4	Concentration of NaSO4- ion pairs, mol L-1.

Table 16.3. List of significant variables of 2DSOIL

Nch	Number of stream or external unit
Ncode	Code indicating the way of data supply for surface nodes.
Ncorn	Number of corner nodes of a particular element.
Nlevel	Number of time levels at which the matrix A and vector B are assembled for solute, heat and gas transport.
Nmat	Number of soil layers (soil materials).
NmatD	Maximum number of soil layers (soil materials).
NodNum(NumLinNod,NumPoint())	Global numbers of nodes for which the information is to be printed.
Npar	Number of parameters specified for each soil layer (soil material)
Nseep	Number of seepage faces expected to develop.
Nsurf	Number of nodes at the soil-atmosphere boundary.
NtabD	Number of entries in the internally generated tables of the hydraulic properties.
NumBP	Actual total number of boundary nodes.
NumBPD	Maximum allowed number of boundary nodes.
NumCell(NumLinCell)	Total numbers of values to be printed in printout lines.
NumEl	Actual number of elements (quadrilaterals and/or triangles).
NumElD	Maximum number of elements in finite element mesh.
NumF	Total number of nodes where the flooding irrigation is applied.
NumFP(NumF)	Global numbers of nodes where the flooding irrigation is applied.
NumGD	Maximum allowed number of gases.
NumLinCell	Total number of horizontal layers of elements
NumLinNod	Total number of transverse grid lines.
NumMod	Total number of modules
NumNP	Actual number of nodal points.
NumNPD	Maximum allowed number of nodes in finite element mesh.
NumPoint(NumLinNod)	Numbers of values to be printed in printout lines.
NumPrint	Number of specified print times.
NumSD	Maximum allowed number of solutes.
NumSEl	Number of subelements (triangles).
NumSol	Actual number of solutes for which the transport is to be simulated.
NumSurfDat	Actual number of values in one line of soil-atmosphere surface data.
NumSurfDatD	Maximum allowed number of values in one line of soil-atmosphere surface data.
NvarBG	Total number of boundary nodes where time-dependent gas contents of fluxes are prescribed.
NvarBS	Total number of boundary nodes where time-dependent solute concentrations are prescribed.
NvarBT	Total number of boundary nodes where time-dependent temperatures or heat fluxes are prescribed

Table 16.3. List of significant variables of 2DSOIL

NvarBW	Total number of boundary nodes where time-dependent water fluxes or pressure heads are prescribed.
OH	Concentration of nonassociated hydroxil ions.
ORG_N	Total amount of N in the form of organic matter, kg ha-1
OSMFAC	Factor describing ability of plant to osmoregulate when water stressed (= change in osmotic potential/change in water potential).
OSMREG	Switch to indicate that osmoregulation should occur (positive value decreases leaf osmotic potential).
P0	Value of pressure head h0 below which roots start to extract water from the soil, cm.
P1	rate of carbon release from organic matter g cm-3 day-1
P12	rate of carbon transfer from organic fertilizer to organic matter g cm-3 day-1
P13	rate of carbon release from organic fertilizers, g cm-3 day-1
P1415	potential rate for carbon transfer to the organic fertilizer and litter pools, g cm-3 day--1
P2	rate of carbon transfer from plant residues to humus, g cm-3 day-1
P2H	Value of the limiting pressure head h2,high below which the roots cannot extract water at the maximum rate (assuming a potential transpiration rate of Ec,high), cm.
P2L	Value of the limiting pressure head h2,low above which the roots can extract water only at the minimum rate (assuming a potentialctranspiration rate of Ec,low), cm.
P3	rate of carbon release from plant residues, g cm-3 day-1
P45	flux of carbon to the litter and organic fertilizer pools, g cm-3 day-1
PARTRT	The proportion of VEGSRC partitioned to the root.
PCO2Nod(NumNP)	Array of nodal carbon dioxide pressure values, atm.
PCRL	Rate at which carbon would be supplied to growing roots in a soil slab if all potential shoot growth had been satisfied, g day-1.
PCRQ	Rate at which carbon would be supplied to growing roots in a soil slab if all translocated carbon went to the roots, g day-1.
PCRS	Actual rate at which carbon is supplied to roots in a soil slab, g day-1.
PCRTS	Sum of potential rates of carbon use by roots in selected soil cells in a soil slab, g day-1.
PDRL	Potential rate of change in root length in soil cell under consideration if carbon is not limiting, cm day-1.
PDWR(NumEl)	Potential rate of increase of root dry weight in soil cell, g day-1.
PERIOD	Length of calculation period under consideration, day.
PG	Kinetic rate constant of the gas exchange between the soil and the atmosphere at the surface, day-1.

Table 16.3. List of significant variables of 2DSOIL

PH	Surface heat flux change per degree of soil surface temperature (bT) for the boundary surface around a node (J d-1 oC-1)
PILD	Leaf osmotic potential at dawn, bar.
PILOSM	Leaf osmotic potential at dawn adjusted for osmoregulation caused by water stress, bar.
POPROW	Plant population per meter of row.
POPSLB	Plant population per soil slab.
POTLOST	potential amount of N lost through immobilization
PPDRL(NumEl)	Value of PDRL for soil cells at previous calculation time.
PPSIL	Value of PSIL_ at previous calculation time.
PPSILT	Leaf water potential which just prevented all shoot growth during the last calculation period, bar.
PRESENT	total amount of solution N at the current node
PROFILE_N	total amount of N in the profile, kg ha-1
PSILD	Leaf water potential at dawn, bar.
PSILT	Leaf water potential which just prevents all shoot growth at time under consideration, bar.
PSILZ	Leaf water potential at zero turgor, bar
PSIL_	Leaf water potential, bar.
PSIM	Average soil moisture potential over cells with active roots, bar.
PSIRD(NumEl)	Water potential in soil cells at dawn, bar.
PSIS(NumEl)	Water potential of soil cells, bar.
PSISM	Soil water potential averaged over cells from which water is extracted when potential shoot growth is satisfied (weighted for the amount of water extracted), bar.
PSIST	Soil water potential averaged over cells from which water is extracted when all carbon translocated goes to the roots (weightedfor the amount of water extracted), bar.
PTPL	TPL at previous calculation time, bar.
Par(10,NMat)	Parameters which describe the hydraulic properties of soil.
Pivot	See listing of the NONLIN subroutine.
Plevel	Number of the next print time.
Poptm(NMat)	Values of the pressure head, cm, below which roots start to extract water at the maximum possible rate.
Q(NumNP)	Nodal values of the recharge/discharge rate, cm2 day-1 for planar flow and cm3 day-1 for axisymmetrical flow.
Q1	Mineralization of N from stable organic matter, g cm-3 day-1
Q12	amount of N immobilizaed during decomposition of organic fertilizer, g cm-3 day-1

Table 16.3. List of significant variables of 2DSOIL

Q13	The rate of N release from organic fertilizer, g cm-3 day-1
Q14	The rate of immobilization of NH4-N in organic fertilizers, g cm-3 day-1
Q1415ACT	the actual rate of immobilization of NO3-N and NH4-N in organic fertilizers, g cm-3 day-1
Q1415POT	the potential rate of immobilization of NO3-N and NH4-N in organic fertilizers, g cm-3 day-1
Q15	the immobilization of NO3-N in organic fertilizer, g cm-3 day-1
Q2	rate of immobilization of N from plant residues in the humus pool, g cm-3 day-1
Q3	the rate of N release from litter, g cm-3 day-1
Q4	the immobilization of solution NH4-N into the litter pool, g cm-3 day-1
Q45ACT	the actual sum of fluxes Q4 and Q5, g cm-3 day-1
Q45POT	The potential sum of fluxes Q4 and Q5, g cm-3 day-1
Q5	The immobilization of solution NO3-N in litter, g cm-3 day-1
Q6	nitrification of NH4-N to NO3-N, g cm-3 day-1
Q7	N lost through denitrification g cm-3 day-1
QF	Current amount of water infiltrated into soil during flooding irrigation event, cm.
QT	factor change in rate with a 10 degree change in temperature
Qa	Moisture content a (see Section 6.3)
Qg	Constant component of the surface gas flux for the given time step, g cm-2 day-1.
Qh	Heat flux component that does not depend on surface temperature, J d-1
Qk	Moisture content k (see Section 6.3)
Qm	Moisture content m (see Section 6.3)
Qn	Actual latent heat of evaporation for for the boundary surface around a node (J d-1)
Qr	Moisture content r (see Section 6.3)
Qs	Moisture content s (see Section 6.3)
R0	C/N ratio of the decomposer biomass and humification products
RADINT(24)	Fractions of solar radiation intercepted hourly by the crop.
RADVEC	Radius vector of the earth.
RAIN	Rainfall, mm day-1.
RGCF(NumEl)	Proportional reductions of root growth from all physical causes in soil cells.
RGCF1	Proportional reduction of root growth caused by mechanical soil resistance and soil water potential.
RGCF2	Proportional reduction of root growth caused by soil temperature.
RGCF3	Proportional reduction of root growth caused by soil oxygen.
RI	Daily solar radiation integral, J m-2.
RINT(24)	Rain intensity hourly, cm day-2.
RL	C/N ratio of plant residues
RM	C/N ratio of organic fertilizer
RNC	Net radiation on the crop assuming complete cover, W m-2.

Table 16.3. List of significant variables of 2DSOIL

RNLU	Net upward long wave radiation, W m-2.
RNS	Net radiation on the soil surface assuming bare soil, W m-2
ROOTFR(NumEl)	Root water uptake activity distribution.
ROUGH	A crop surface roughness parameter.
ROWANG	Row orientation measured eastward from north, degrees.
ROWINC(20)	Distance between a row and the midpoint of an increment of rowspacing, cm.
ROWSP	Row spacing, cm.
RRRM	Radial resistance of old roots per cm of root, bar day g-1.
RRRY	Radial resistance of young roots per cm of root, bar day g-1.
RTMINW	Minimum dry weight of root that must be present in a cell before it can grow into adjacent cells, g.
RTWL	Average root dry weight per unit length, g cm-1.
RTWT(NumEl)	Dry weight of root in soil cells, g.
RUTDEN(NumEl)	Root density in soil cells, cm cm-3.
RVR(NumEl)	Root vascular resistance between base of stem and soil cells, bar day g-1.
RVRL	Root vascular resistance per cm of root, bar day g-1.
Radd	Correction in solute movement equations to accomodate solute content in rain water.
SARANG(24)	Angle between row orientation and solar azimuth hourly, radians
SCF	Stomatal closure factor for reducing H2O and CO2 flux.
SDERP(9)	Empirical regression coefficients for calculating solar declination.
SED(3)	Contents of gypsum, calcite and magnesite in array, mol of solid salt L-1
SGT	Proportion of time for which shoot grows: limited by shoot turgor.
SGTLI	Proportion of shoot growing time lost irretrievably because of ow turgor.
SGTLT	Proportion of shoot growing time lost temporarily while turgor is decreasing. It is regained when turgor increases.
SHADE	Width of the shaded strip on the soil surface.
SHADOW(24)	Hourly width of shadow cast by crop row measured at rightangles to the row, cm.
SINALT(24)	Sine of solar altitude hourly.
SINAZI(24)	Sine of solar azimuth hourly
SO4	Concentration of non-assosiated sulphate ion in the solution, mol L-1
SOLALT(24)	Solar altitude hourly, radians.
SOLAZI(24)	Solar azimuth hourly, radians.
SR(NumEl)	Soil resistance to water flow to roots in soil cells, bar day g-1.
SVPW	Water saturation vapor pressure at the wet bulb temperature, kPa.
Sc(NumNP)	Area around a node where the node-associated sink term is valid
Sca	Exchangeable calcium content, eq L-1.
SelCoefCaNa	Array of nodal selectivity coefficients of cation exchange Ca - Na for the Gaines-Thomas isoterm equation, (mol L-1)-1/2.
SelCoefMgNa	Same as above for the Mg-Na exchange.

Table 16.3. List of significant variables of 2DSOIL

Sink(NumEl)	Values of water extraction rates for elements, day-1.
SinkE	Water extraction rate for an element, day-1.
Smg	Exchangeable magnesium content, eq L-1.
Sna	Exchangeable sodium content, eq L-1.
Step	Time step value, day.
Str	Ionic strength of the solution, mol L-1.
TAIR(I)	Air temperature hourly, oC.
TB	base temperature at which ET=1, oC
TCAIR	Thermal conductivity of dry air, mcal cm-2 s-1 oC-1
TCH2O	Thermal conductivity of water, mcal cm-2 s-1 oC-1
TCSAT	Thermal conductivity of air with water vapor, mcal cm-2 s-1 oC-1
TCSxx(NumNP)	'x' component of thermal conductivity of the soil, J cm-2 d-1 oC-1
TCSzz(NumNP)	'z' component of thermal conductivity of the soil, J cm-2 d-1 oC-1
TCVAP	Thermal conductivity of water vapor, mcal cm-2 s-1 oC-1
TDRY	Dry bulb temperature, oC.
TDUSK	Air temperature at sunset, oC.
TDUSKY	Air temperature at sunset yesterday, oC.
TEND	Proportion of total daily solar radiation received in the period during which dawn or dusk occurs.
TESAZI	Solar azimuth (SOLAZI) calculated for the current hour angle (HRANG) decremented by 0.01. It is used to test if azimuth is decreasing, in which case azimuth is being calculated incorrectly because it is less than /2, radians.
TETC(NMat,MCON)	Measured soil hydraulic conductivity values, cm day-1.
TETR(NMat,MREL)	Measured soil moisture contents at water retention curve.
THD	threshold water content at which no denitrification occurs
THH	intermediate value for calculating the correction factors for nitrogen transformations
THL	intermediate value for calculating the correction factors for nitrogen transformations
THW	Wilting point water content cm3/cm3
TH_D	exponent used to calculate dependence of ED on theta.
TH_M	exponent used to calculate dependence of Etheta on water content
TMAX	Maximum air temperature during the day, oC.
TMAXHR	Time of maximum air temperature measured from dawn, hr.
TMIN	Minimum air temperature during the day, oC.
TMINT	Minimum air temperature during the next day, oC.
TOTNIT	total amount of nitrogen during current time step in current node, g cm-3
TOTNITO	total amount of nitrogen during past time step in current node, g cm-3
TPI	2 * pi = 6.2832185.
TPL	Leaf turgor pressure, bar.
TPLD	Leaf turgor pressure at dawn, bar.

Table 16.3. List of significant variables of 2DSOIL

TPLT	Leaf turgor pressure which just prevents all shoot growth at time under consideration, bar.
TPRD(NumEl)	Root turgor pressures at dawn minus the threshold turgor for growth, bar.
TS(NumEl)	Temperature of soil in elements, oC.
TSO4	Total amount of SO42- ions in all soil phases, mol L-1 of soil solution.
TWET	Wet bulb temperature, oC.
Tca	Total amount of calcium in all soil phases, mol L-1 of soil solution.
Tcl	Same as above for the cloride ion.
Tfin	Time of the end of simulations, day.
ThAMin(NMat)	Minimum values of air-filled porosity
ThANew(NumNP)	Nodal air-filled porosity value at the new time level.
ThAOld(NumNP)	Same as above for the old time level.
ThATr(NMat)	Threshold values of air-filled porosity.
ThNew(NumNP)	Nodal values of the water content at the new time level.
ThOld(NumNP)	Nodal values of the water content at the old time level.
ThTot(NMat)	Porosity of soil materials.
TheTab(NTab,NMat)	Internal table of the soil water content.
Theta(NumNP)	Intermediate values of soil moisture content.
ThetaA(NumNP)	Nodal values of air-filled porosity.
Thta(NumNP)	Nodal soil water contents.
Ti	Interpolated soil moisture content.
Time	Common time value of all modules.
Tinit	Time of the beginning of calculations, day.
Tmg	Total amount of magnesium in all soil phases, mol L-1 of soil solution
Tmpr(NumNP)	Nodal soil temperature values, oC.
Tna	Total amount of sodium in all soil phases, mol L-1 of soil solution.
TolAbs	Absolute pressure head tolerance limit, cm.
TolRel	Relative pressure head tolerance limit.
Total(5)	Array of total amounts of conservative ions in the chemical system: Total(1), Total(2), Total(3), Total(4), Total(5) correspond to Ca2+, Mg2+, Na+, SO42-, Cl-, respectively.
Totl	Same as above.
Tpot	Potential transpiration from the unit area, cm day-1.
Trel	Time from emergency, day.
VALUE(N)	See listing of the subroutine SORT.
VEGSRC	Rate of carbon supply to the vegetative parts of the shoot and root, g plant-1day-1.
VH2OC(NumEl)	Volumetric water contents of soil cells, cm3 cm-3.
VMAX	Maximum value of VEGSRC.
VPD(24)	Water vapor pressure deficit hourly, kPa.
VSind(NMatN)	Volumetric fraction of sand and silt (%)

Table 16.3. List of significant variables of 2DSOIL

Vabs	Absolute value of the nodal Darcy fluid flux density, cm day-1.
VarB	Time-dependent pressure head or water flux in a particular surface node
VarB1	Surface temperature or surface gas content at the time-dependent boundary.
VarB2	Kinetic rate of the heat exchange or gas exchange between the soil slab and outer space at the time dependent boundary.
VarB3	Soil-independent component ofthe heat exchange or gas exchange between the soil slab and outer space at the time dependent boundary.
VarBG(NumBP,3)	Current boundary values for gas transport (VarB1, VarB2, VarB3).
VarBS(NumBP,NumS)	Current boundary concentrations of solutes
VarBT(NumBP,3)	Current boundary values for heat transport (VarB1, VarB2, VarB3).
VarBW(NumBP,3)	Current boundary values for water transport.
Vclay(NmatN)	Volumetric fraction of clay (%)
VorgM(NMatN)	Volumetric fraction of organic matter (%)
Vx(NumNP)	Nodal values of the x-component of the Darcian velocity vector, cm day-1.
VxE	The x-component of the Darcian velocity vector for an element, cm day-1.
VxH(NumNP)	Same as Vx at new time level.
VxOld(NumNP)	Same as Vx at new time level.
Vxx	The 'x' component of the Darcian velocity vector, cm day-1.
Vz(NumNPD)	Nodal values of the z-component of the Darcian velocity vector, cm day-1.
VzE	The z-component of the Darcian velocity vector for an element, cm day-1.
VzH(NumNP)	Same as Vz at new time level.
VzOld(NumNP)	Same as Vz at new time level.
Vzz	The 'z' component of the Darcian velocity vector, cm day-1.
W	Nodal value of volumetric soil moisture content.
WATACT	Actual radiation incident at earth's surface at noon, W m-2.
WATATM	Radiation incident at the top of the atmosphere at noon, W m-2.
WATPL	Total radiation intercepted by the crop canopy expressed as equivalent radiation from one direction, W m-2.
WATPOT	Potential radiation incident at earth's surface at noon, W m-2.
WATRAT	Proportion of radiation that can penetrate the cloud cover (=WATACT/WATPOT).
WATTSM(24)	Actual radiation incident at earth's surface hourly, W m-2.
WIND	Windspeed at 2 metres, km hr-1.
WINDA	Average windspeed for the territory under consideration
WINDL	Effective windspeed as augmented by convection currents, km hr-1.
WUP0S	Rate of water uptake from a soil slab when leaf turgor pressure equals to zero bar, g day-1.
WUP2S	Rate of water uptake from a soil slab when leaf turgor pressure equals to 2 bar, g day-1.

Table 16.3. List of significant variables of 2DSOIL

WUPDS	Rate of water uptake from a soil slab if leaf water potential has notrisen above the threshold which just prevented all shoot expansion in the last period, g day-1.
WUPGS	Rate of water uptake from a soil slab for various values of leaf water potential. Used to select a value of leaf water potential iteratively, g day-1.
WUPM(NumEl)	Rate of water uptake from soil cells by roots more than 0.2 days old, when leaf water potential is at the threshold, i.e., prevents shoot growth, g day-1.
WUPMS	Sum of WUPM(NumEl) and WUPN(NumEl) over all soil cells in a soil slab, g day-1.
WUPN(NumEl)	Rate of water uptake from soil cells by young roots when leaf water potential is at the threshold, i.e., prevents shoot growth, g day-1.
WUPRS	Rate of water uptake from a soil slab by new roots grown after shoot growth potential has been satisfied, g day-1.
WUPSI	Sum of (soil water potential) * (rate of water extraction) over cells in a soil slab from which water is extracted, bar.g day-1.
WUPT(NumEl)	Rate of water uptake from soil cells when leaf water potential is at the threshold, i.e., prevents shoot growth, g day-1.
WUPTS	Rate of water uptake from a soil slab by new roots grown when all translocated carbon goes to the roots, g day-1.
WW	Same as W.
Wa	Weighing factor for the upper adjacent cell to find the proportion of new roots proliferating to this cell from given one.
Wb	Same as Wa for the lower adjacent cell.
WeTab(3,2*NumEl)	Weighing factors associated with the sides of subelements.
WeightCell	Weight of a given soil cell in the distribution of its root mass increment between the given cell and its neighbors.
WeightLeft	
WeightLower	Same as above for the lower adjacent cell
WeightRight	
WeightUpper	Same as above for the upper adjacent cell
Width(NumBP)	Width of the boundary strip associated with boundary nodes, cm, for planar flow; area of this strip, cm2, for the axisymmetrical flow.
WidthE	Array of maximum horizontal sizes of soil cells.
Wl	Same as Wa for the 'Left' adjacent cell. The 'Left' adjacent cell is in the same horizontal layer of cells as a given one, and is closer to stem base than given cell.

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Wr	Same as Wa for the 'Right' adjacent cell. The 'Right' adjacent cell is in the same horizontal layer of cells as a given one, and is further from stem base than given cell.
Wx	Upstream weighing factor for the tranverse direction.
Wz	Same as above for the vertical direction.
XAIR	Weighting factor ( ) for thermal conductivity of air
XCLAY	Weighting factor ( ) for thermal conductivity of clay
XGAIR	Relative proportion of water in pores
XION	Array of concentrations of non-associated ions in the solution.
XLAT	Latitude, radians.
XMUCK	Weighting factor ( ) for thermal conductivity of organic matter
XSIND	Weighting factor ( ) for thermal conductivity of sand and silt
XTEMP	Constant controlling the rate at which air temperature falls after dusk, oC. Temperature falls more slowly as XTEMP increases.
YRL(NumEl)	Length of young root in soil cells, cm.
aCO3	Same as above for the carbonate ions.
aCa	Activity of calcium ions in the solution.
aCl	Activity of chloride ions in the solution.
aHCO3	Same as above for the bicarbonate ions
aMg	Activity of magnesium ions in the solution.
aNa	Activity of sodium ions in the solution.
aOH	Same as above fot the hydroxyl ions.
aSO4	Activity of sulphate ions in the solution.
aa1	Coefficient in the zero degree term in the cubic polynomial.
aa2	Same as above in the first degree term.
aa3	Same as above in the second degree term.
aa4	Same as above in the third degree term.
alf	Weight of values at old time level in temporal discretization.
alpha	parameter for equation to obtain carbon fixed by light (mg CO2/umole photons)
alphar	Scale factor for gas uptake
bTort	Tortuosity change per unit of air-filled porosity (See Section 9).
cBnd	Boundary solute concentration for solute transport, g per cm-3
cSink(NumEl)	Solute extraction rates, g cm-3 day-1.
carbon_t	Total carbon used by the above ground plant ,g per plant
dMul1	Dimensionless number by which time step is multiplied if the number if iterations is greater than or equal to 7
dMul2	Dimensionless number by which time step is multiplied if the number if iterations is less than or equal to 3
dlh	Spacing (logarithmic scale) between consecutive pressure heads in the internally generated tables of the hydraulic properties.

Table 16.3. List of significant variables of 2DSOIL

dt	Time step, day.
dtMax	Maximum permitted time step, day.
dtMin	Minimum permitted time step, day.
dtMx(4)	Maximim time steps allowed by transport modules, day.
dtOld	Previous time step, day.
eorscs	Cumulative value of EORSCF
eps(6)	Set of tolerable errors
epsA	Tolerable relative error of activity coefficients.
epsN	Tolerable residual for nonlinear solver NONLIN.
epsP	Tolerable error of activity products.
epsi	Weight of values at new time level in temporal discretization.
err	Switch to show if there is an error in input data.
gair	Concentration of gas in the air (ppm)
gamma	Psychrometric constant (kPa /C)
hSat(NMat)	Air entry values for soil layers, cm.
hTab(NTab)	Internal table of the pressure heads, cm
hTab1	Lower limit [L] of the pressure head interval for which tables of hydraulic properties are generated, cm
hTabN	Upper limit of the pressure head interval for which tables of hydraulic properties are generated, cm.
hTemp(NumNP)	Nodal values of the pressure head, cm, at the previous iteration.
hcrita	Critical Pressure head at the soil surface for evaporation
hcrits	Critical pressure head at the soil surface for infiltration
iCheck	Switch that shows if at least one node at the seepage face has became saturated
iFavRoot(NumEl)	Array of element (cell) numbers from the best to the worst conditions for root activity.
iForm	Code of the printout format
iLeft	Number of the element neighboring to given one from its left side; it is equal to the number ob the given element for elements at the left boundary of the soil slab.
iLower	Number of the element neighboring to given one from its bottom side; it is equal to the number ob the given element for elements at the bottom boundary of the soil slab.
iRight	Number of the element neighboring to given one from its right side; it is equal to the number ob the given element for elements at the right boundary of the soil slab.

Table 16.3. List of significant variables of 2DSOIL

iUpper	Number of the element neighboring to given one from its upper side; it is equal to the number ob the given element for elements at the upper boundary of the soil slab.
ir0	Seed for the random generator.
jjj	Current number of solute or gas.
lConst	Logical variable indicating whether or not there is a constant number of nodes at any transverse line.
lInput	Shows a stage of calculations: = 1, if only initial and time independent data are read;= 0, if time step is to be done.
lUpW	Logical variable indicating if upstream weighing or the standard Galerkin formulation is to be used.
light_i	Light intensity
movers(n)	Array of transport process subroutines
msw6	Switch to indicate if relative humidity is available
nbpC(MLAY)	Number of points in the interpolation table for the hydraulic conductivity.
nbpR(MLAY)	Number of points in the interpolation table for the water retention.
ndef	Nitrogen stress factor
nfrac	cumulative fraction of N in plant tissue
nitrogen_t	Total nitrogen uptake by the plant, g per plant
nshoot	Switch to indicate above ground plant growth (1 if plant growth is simulated)
p_vegsrc	Actual rate of carbon fixation (g/plant /day)
p_vmax	Maximum rate of carbon fixation (g/plant/day)
parint(12)	Fraction of light intercepted by crop at time i
pcarbon_t	Potential carbon production, g per plant
popare	Plant population per unit area (m2)
propar	Proportion of photo synthet active light on outside of crop canopy
psh	Switch to indicate of node is covered, 1 if yes
r2H	Critical potential transpiration rate Ec,high, cm.
r2L	Critical potential transpiration rate Ec,low, cm.
rel_humid	value of relative humidity
sincrsink	Cumulative solute uptake, g
svpa	Water saturation vapor pressure at the wet bulb termperature (kPa)
t	Time at current time level, day.
tBnd	Temperature at the boundary node when temperature at the boundary node is given, oC
tFix	Next time resulting from time discretizations rules No.2 and No.3, day
tKod	Boundary code for heat set in HeatMover.1=Dirichlet boundary condition 3=Cauchy
tNext	Array of time values at which a modules require to choose a new time step value - obligatory time step end times.

Table 16.3. List of significant variables of 2DSOIL

tOld	Time at the previous time level, day.	
tPrint	Array of times when output must be done, day.	
tRigid	Minimum of tNext values.	
tTDB(4)	Times to alter time-dependent boundary conditions for transport modules.	
tatm	Time of the next alteration of soil-atmosphere boundary values.	
tau	Tortuosity factor.	
tau	Parameter in equation to obtain carbon fixed from light (m/s)	
thR(NMat)	Residual water contents.	
thSat(NMat)	Saturated water contents.	
total_carbon	Total Carbon fixed by plant (g/plant)	
total_eor	Total water uptake by plants in a strip 1 cm wide and the width of a row	
total_pcrs	Total Carbon used to grow roots g/half soil slab)	
totssink	Cumulative chemical uptake by plant roots (g/d)	
totwsink	Cumulative water uptake by roots (g/half soil slab 1 cm wide)	
tsink	Heat sink	
ucarbon		0
ucarbon_t		0
wincrsink	Total water uptake during a time step (cm3/ 1 cm wide half slab)	
x(NumNP)	'x' coordinates of the nodal points, cm.	
xBSTEM	'x' coordinate of the plant stem base, cm.	
xMean	Horizontal distance between of the element center of gravity and plant stem base, cm.	
xMul	Modifying factor to transform equations of planar flow to equations of axisymmetric flow, cm.	
xgc	Horizontal coordinate of the center of gravity of an element.	
y(NumNP)	'y' or 'z' coordinates, cm, of the nodal points.	
yBSTEM	Vertical coordinate of the plant stem base, cm.	
yMean	Vertical distance between of the element center of gravity and plant stem base, cm.	
ygc	Vertical coordinate of the center of gravity of an element.	
zsize	See listing of the WSMPLX subroutine.	

Table16.4.Exampleofthe'RefVar.lst'filecontent

Variable	Module	Subroutine	Alteration	
A	solmov.for	SoluteMover		X
	solmov.for	WeFact		X
	watmov.for	WaterMover		X
	watmov.for	Veloc		X
	gasmov.for	GasMover		X
	setmat01.for	FK		
	setmat01.for	FC		
	setmat01.for	FQ		
	setmat01.for	FH		
	setmat02.for	qeq	X	
	setmat02.for	prep	X	
aa	solmov.for	WeFact		X
aa1	setmat02.for	qeq		
aa2	setmat02.for	qeq		
aa3	setmat02.for	qeq		
aa4	setmat02.for	qeq		
Ac	solmov.for	SoluteMover		X
	gasmov.for	GasMover		X

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