DOCUMENTATION FOR PREPARING THE INPUT FILE OF THE UPDATED HYDRUS PACKAGE FOR MODFLOW-2000

Updated May 2008

Navin Kumar C. Twarakavi[1], Hyeyoung Sophia Seo[2] and Jirka Simunek[1]

[1] *University of California, Riverside, 900 University Ave. Riverside CA 92521, Jiri.Simunek@ucr.edu*
[2] *Colorado School of Mines, 1500 Illinois St. Golden* CO 80401, hseo@mines.edu, *epoeter@mines.edu*

The input to the HYDRUS Package is read from the file that is type "UNSF" in the name file. Note that the HYDRUS package comes with an author supplied template for ease in preparing the package input file. The input files may have any number of comment lines. Unlike other MODFLOW packages, the HYDRUS package can have any number of comment lines. However, each comment line must be distinguished by starting it with a '#' sign. Input in '[ ]' is not mandatory and is required under some conditions.

FOR EACH SIMULATION

0. [#Text]
1. NPUNSP NUNSFOP IUNSFCB IUNSFpr
2. NMAT MAXNP MAXATM
3. Zonarr
4. MaxIt TolTh TolH
5. DT DTMIN DTMAX DMUL DMUL2 ITMIN ITMAX
6. HTAB1 HTABN iMODEL
7. THR THS ALPHA N KS L (Repeat item 7 NMAT times.)
8. PROPR
   [PROINF]
   [PRINT TIMES, must be repeated PROpr times]

FOR EACH PROFILE

9. [IZ]
10. SINKF WLAYER LINITW NOMAT
11. NUMNP
12. N Z(n) H MAT BETA
    (Repeat item 11 NUMNP times.)
13. [P0 P2H P2L P3 r2H r2L POPTM]
    (Read when SINKF ≥ 0.)
14. MAXAL hCritS
15. tAtm Prec rSoil rRoot hCritA
    (Repeat item 14 MAXAL times.)

EXPLANATION OF VARIABLES

Text	Character variable (199 characters) that starts in column 2. Any characters can be included in Text. The "#" character must be in column 1. Text is printed when the file is read.
NPUNSP	Number of unsaturated flow profiles.
NUNSFOP	Unsaturated flux option code. The flux is either applied to the first layer in each vertical column or to the highest active layer. 1; Unsaturated flux is applied to layer one. 2; Unsaturated flux is applied to the highest active layer in each vertical column.
IUNSFCB	Flag and a unit number. If IUNSFCB > 0, it is the unit number to which cell-by-cell flow terms will be written when "SAVE BUDGET" or a non-zero value for IUNSFCB is specified in Output Control. If IUNSFCB ≤ 0, cell-by-cell flow terms will not be written.
IUNSFpr	Output flag. The possible values of IUNSFpr and their meanings are as follows: If IUNSFpr = 0, then only input is printed. If IUNSFpr = 1, then an echo of input and the fluxes from the UNSF package are printed at the end of each time period. If IUNSFpr = 2, then no input is echoed but fluxes are printed at the end of each time step.
NMAT	Total number of soil materials in the model domain. Materials are identified by the material number, MatNum.
MAXNP	Maximum number of nodal points in a HYDRUS profile.
MAXATM	Maximum number of atmospheric data.
Zonarr	Name of the zone array to be used to define the cells that are associated with each profile. The name "ALL" means that there is no zone array and one HYDRUS profile is used for all MODFLOW grid cells. The name "EACH" means that the HYDRUS profile is used for each MODFLOW grid cell.
MaxIt	Maximum number of iterations allowed during any unsaturated flow calculation time step, while solving the nonlinear Richards' equation using a modified Picard method. The suggested value is 20.

TolTh — Absolute water content tolerance for nodes in the unsaturated flow model (the suggested initial value is 0.0001). *TolTh* represents the maximum desired absolute change in the value of the water content between two successive iterations during a time step. If the numerical solution does not converge, the user may try to relax these criteria, or use finer discretization.

TolH — Absolute pressure head tolerance for nodes in the saturated flow model (its recommended initial value is 0.1cm). *TolH* represents the maximum desired absolute change in the value of the pressure head between two successive iterations during a particular time step. If the numerical solution does not converge, the user may try to relax these criteria, or use finer discretization.

DT — Initial time increment, Δt [T]. Initial time step should be estimated with respect to the problem being solved. For problems with high pressure gradients (e.g. infiltration into and initially dry soil), Δt should be relatively small.

DTMIN — Minimum permitted time increment for the unsaturated zone model, Δt_{min} [T].

DTMAX — Maximum permitted time increment for the unsaturated zone model, Δt_{max} [T].

DMUL — Dimensionless number to multiply Δt for the next time step when the number of required iterations at a particular time step is less than or equal to *ITMIN*. The recommended value ranges between 1.0 and 1.3.

DMUL2 — Dimensionless number to multiply Δt for the next time step when the number of required iterations at a particular time step is less than or equal to *ITMAX*. Usually *DMUL2* is less than 1.0, and the recommended value is 0.7.

ITMIN — Lower optimal iteration range. When the number of iterations necessary to reach convergence for water flow is less than or equal to this number, the time step is multiplied by a dimensionless number *DMUL*. Recommended value is 3.

ITMAX — Upper optimal iteration range. When the number of iterations necessary to reach convergence for water flow is higher than this number, the time step is multiplied by a dimensionless number *DMUL*2. Recommended value is 7.

HTAB1 — Absolute value of the upper limit [L] of the pressure head interval below which a table of hydraulic properties will be generated internally for each material (*HTAB*1 must be greater than 0.0; e.g. 0.001cm).

HTABN Absolute value of the lower limit [L] of the pressure head interval for which a table of hydraulic properties will be generated internally for each material (e.g. 1000m). If the absolute value of the pressure head during program execution lies outside of the interval [*HATB1, HTABN*], then appropriate values for the hydraulic properties are computed directly from the hydraulic functions (i.e. without interpolation in the table).

iModel Soil hydraulic properties model:
= 0; van Genuchten
= 1; van Genuchten with air entry value of 2 cm
= 2; Brooks and Corey

THR Residual water content.

THS Saturated water content.

ALPHA Inverse of the air-entry value (or bubbling pressure)
N Pore size distribution index
L Pore-connectivity parameter

KS Saturated hydraulic conductivity.

PROPR A flag that allows for printing HYDRUS profile information at selected print times. The profiles are printed in 'profile.out'.
≤0; Profile information not printed.
>0; Profile information printed for PROPR number of times.

PROINF A flag that indicates what kind of profile information has to be printed,. This is required only if PROPR >0.
≤0; pressure heads at each node is printed.
>0; water contents are printed.

PRINT TIMES A line with the times (number of times=PROPR) at which the profile information needs to be printed.

IZ Zone number that defines the cells associated with the profile. These values are omitted if Zonarr is specified as "ALL" or "EACH". The HYDRUS Profile starts with a cell at column 1 and row 1 and moves to column 2 and row 1.

SINKF Root water uptake flag.
If SINKF ≥ 0, water extraction from the root zone occurs.
If SINKF < 0, no water extraction from the root zone.

WLAYER Water accumulation flag.

	If WLAYER ≥ 0, water can accumulate at the surface (There is no surface runoff). If WLAYER < 0, any excess water on the soil surface will be immediately removed (It is assumed to runoff).
LINITW	Initial condition flag. If LINITW ≥ 0, the initial condition is given in terms of water content. If LINITW < 0, the initial condition is given in terms of pressure head.
NOMAT	Number of soil materials in the profile.
NUMNP	Number of nodal points.
N	Nodal number. Nodes are numbered sequentially from 1 to *NumNP* (total number of nodes) from the soil surface to the bottom of the soil profile.
Z(n)	*Z*-coordinate of node *n*. *Z*=0 at the sea level.
H	Initial value of the pressure head at node *n* expressed in terms of height of a column of water.
MAT	Index for material whose hydraulic properties are assigned to node *n*.
BETA	Value of water uptake distribution, *b(z)* [L^{-1}], in the soil root zone at the node n. Set beta (*n*) equal to zero if node *n* lies outside the root zone. *b(z)* is the normalized water uptake distribution in the equation (39).
P0	Value of the pressure head below which the roots start to extract water from the soil. Required if SINKF≥0.
P2H	Value of the limiting pressure head at which the roots cannot extract water at the maximum rate (assuming a potential transpiration rate of *r2H*). Required if SINKF≥0.
P2L	Value of the limiting pressure head at which the roots cannot extract water at the maximum rate (assuming a potential transpiration rate of *r2L*). Required if SINKF≥0.
P3	Value of the pressure head below which root water uptake ceases (usually equal to the wilting point). Required if SINKF≥0.
r2H	Highest potential transpiration rate [LT^{-1}]. Required if SINKF≥0.
r2L	Lowest potential transpiration rate [LT^{-1}]. Required if SINKF≥0.

POPTM	Value of the pressure head below which roots start to extract water at the maximum possible rate. Required if SINKF≥0.
MAXAL	Number of atmospheric data records.
hCritS	Maximum allowed pressure head at the soil surface (usually 0.0).
tAtm	Time for which the i-th atmospheric data record is provided [T]. Time is specified relative to the start of the MODLOFW simulation.
Prec	Precipitation rate [L/T]. *Prec*, *rSoil*, and *rRoot* are always positive. If a negative value is entered, the absolute value will be used.
rSoil	Potential evaporation rate in absolute value [L/T].
rRoot	Potential transpiration rate in absolute value [L/T].
hCritA	Absolute value of the minimum allowed pressure head at the soil surface [L] (defined from equilibrium conditions between soil water and atmospheric vapor).