Differences between SWAT99.2 and SWAT2000

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Theoretical changes:

1) All processes that require a random number use the random number generator described in Bradley, Fox and Schrage. 1983. A guide to simulation. Springer-Verlag, New York. p. 199-202. Also the random number seeds are now dimensioned to the # of HRUs. Every time the random number generator is used, the random number seed is updated to a new number. Previously, the use of one seed for all HRUs would cause different precipitation/sediment yields etc. to be calculated for different HRUs (assuming all inputs identical) when in reality they should be the same. Giving each HRU an independent seed eliminated this problem.
2) Weather generator in SWAT replaced with WXGN weather generator. The new weather generator uses standard deviation instead of skew coefficient for temperature generation. This eliminates erroneous values generated in areas where the mean monthly temperature is at or near zeros. (Skew coefficient is the standard deviation divided by the mean temp).
3) SWAT will now allow solar radiation, wind speed, and relative humidity data to be read from an input file or generated. In previous versions, daily values for these variables were always generated. This feature allows users to incorporate measured data or gives them the ability to use input created from a different weather generator program. As with the precipitation and temperature, different values for solar radiation, wind speed and relative humidity may be specified for different subbasins.
4) Calculations were modified for latent heat of vaporization, psychrometric constant, saturated vapor pressure at a given temperature, and the slope of the saturation vapor pressure curve. These modifications were made to obtain a reference for the equations used—the results between the old and new equations did not differ greatly.
5) The model will now read in sub-daily precipitation data (required only if Green & Ampt infiltration is being used).
6) Changed maximum radiation calculation to account for eccentricity of the earth's orbit around the sun.
7) Previously, when calculating net radiation, the value was not allowed to go below zero. In reality, net radiation can be negative (more outgoing than incoming). This limitation was removed.
8) Previously, the height of wind speed and psychrometric measurements were assumed to be 10 m. They are now assumed to be at 1.7 m.

9) Reviewed all potential evapotranspiration methods. Modifications were made to all calculations. In the Priestley-Taylor method, net short-wave radiation was being used instead of net radiation (corrected), default values for the latent heat of vaporization and the psycrometric constant were used (now use daily calculated values). In Penman-Monteith, the calculation of aerodynamic resistance has been changed, the calculation of zero-plane displacement has been changed, the roughness length term has been split into the roughness length for momentum transfer and the roughness length for vapor transfer, and the potential ET calculation is made assuming a 40cm alfalfa cover. In Hargreaves method, the exponent was changed from 0.6 to 0.5 (the original). Also, the model will now read in daily potential ET values as an alternative to using one of the three methods defined—this allows the user to implement a different potential ET method if desired.
10) Elevation band processes reviewed and updated. Model now requires elevation of precipitation and temperature gages to be given. This information is needed to correctly estimate the amount of rainfall/temperature for a given elevation band in a subbasin. Prior to this change, the elevation in the wgn file was assumed to be the same as the elevation of the precipitation and temperature gages. Sublimation in elevation bands now occurs only when the temperature is greater than 0°C (same as for subbasins without elevation bands).
11) Changed soil temperature calculations to match those in EPIC. (Not a significant change in results)
12) Green & Ampt infiltration method has been incorporated as an alternative to the curve number method for surface runoff.
13) Changed calculation of 0.5 hr highest intensity rainfall and peak rate to match those used in EPIC. These new calculations do not require RAIN_HH and RAIN_6H, values that are difficult to obtain in many areas of the world. If sub-daily precipitation is used, the 0.5 hr highest intensity rainfall is calculated from the precipitation data.
14) Corrected errors found in equations used to calculate transmission losses in tributary channels.
15) Sediment yield from an HRU is now adjusted for snow cover protection.
16) A harvest efficiency for a Harvest Only operation can be defined.
17) Allow user to input organic N and organic P enrichment ratios used to calculate amount of organic N & P removed in surface runoff. (If the user doesn't enter an enrichment ratio, the model calculates an enrichment ratio for each storm event. In previous versions, the model-calculated enrichment ratio was always used)
18) A nutrient concentration in groundwater may be defined. This allows users to calibrate in-stream nutrient concentrations during low flow periods.
19) Ponds may no longer be placed on the main channel; they are always located within a subbasin. (They were previously allowed to be located on the main channel because only 6 reservoirs could be defined. In SWAT2000, an unlimited number of reservoirs may be defined, so the ability to locate ponds on the main channel is no longer needed.)

20) Moved pond and wetland subroutines to end of the subbasin command loop. Previously, the nutrient calculations for the ponds were not being performed because the pond subroutine was called before nutrient loadings in surface runoff were calculated.
21) The equation used to calculate sediment settling in ponds, wetlands and reservoirs assumed the daily sediment concentration was always equal to or greater than the normal sediment concentration. If the actual sediment concentration was less than the normal concentration defined for the water body, the equation would cause an increase in concentration. Changed calculation so that equation is used only if the actual concentration is greater than the normal concentration. Also, calculate sediment in outflow after calculating sediment settling (order was previously reversed).
22) Saturation dissolved oxygen content of surface runoff was undefined. Added equations to define the max dissolved oxygen content.
23) Added "pothole" processes. A pothole is a depression that drains inward (does not drain into the stream network) or am impounded area such as a rice paddy. These areas are simulated as a plant growing in water over a soil. Evaporation from the water surface is limited as the plant leaf area expands.
24) Reach water routing:
    a) added Muskingum routing method
    b) allow water routing to be performed daily or hourly
    c) changed flow calculation to use volume of water in reach to determine depth (using channel dimensions) and from depth use Manning's equation to determine rate of flow for the day or the hour. Previously, the model assumed that all water entering a reach on a given day was routed through the reach by the end of the day.
25) QUAL2E main channel transformation calculations were reviewed and the following changes made:
    a) changed if statement from flowin volume > 0.1 to flowout rate > 0.01 for performing water quality calculations
    b) changed equation for algi from: algi = ra_btu / dayl(jrch)
       to: algi = ra_btu * tfact / dayl(jrch)
       QUAL2E documentation states that option 2 is not supposed to use tfact, in equation for algi, but that is because the radiation the user enters is supposed to be photosynthetically active radiation. Since SWAT is using net radiation, tfact needs to be included.
    c) in equation for fl_1, variables k_l and algi had different units k_l (kJ/(m2*min)) and algi (Btu/(ft2*hr)); changed units on both to MJ/(m2*hr)
    d) masses of nutrients leaving reach were being calculated by multiplying the concentration by the amount of water flowing in; changed to multiplying by the water flowing out
    e) created local variables to hold values for bc1 and bc2 modified for low oxygen concentrations; before the original values were getting overwritten and lost
    f) change equations so that initial concentrations in reach are used to calculate end of day concentrations for all constituents

26) Provided conservative nutrient routing in reach as an option to QUAL2E transformations.
27) The outgoing sediment yield in the reach was previously initialized to the incoming sediment load. Now outgoing sediment yield is initialized to zero.
28) Changed pesticide routing in reach to allow storage of pesticide in reach.
29) When irrigation water was removed from reservoir, the irrigation was not checked against timing and stress—if the reservoir had the water amount, the model was applying. This was corrected so that irrigation occurs only on proper days or stress level. Also, water applied to HRUs was not subtracted from the volume in the reservoir. This was corrected. (Note: this problem only occurred when a reservoir was specified as the irrigation source. There were no problems with the other irrigation source calculations)
30) Added conservative metal, bacteria, NH_3 and NO_2 loading options to point source files.
31) Aeration of water caused by structures along the main channel can now be modeled.
32) Dormancy period during winter for cool-season plants was previously set to the period of the year when the daylength was within 1 hr of the minimum daylength. This caused problems near the equator where there was very little variation in daylength throughout the year. The model now sets the threshold between 0.0 hrs (no dormancy) and 1.0 hr based on the latitude.
33) Checks have been added to soil water percolation calculations to make sure that the amount of water stored in each soil layer never exceeds the maximum possible value.
34) ***2/1/2001 update:*** Root depth calculated for annuals was allowed to go below the maximum root depth defined for soil/plant. This has been corrected.
35) ***2/1/2001 update:*** Nutrient uptake for all plants was allowed for entire soil profile; now nutrients may be removed only from the root zone.
36) ***2/1/2001 update:*** Radiation-use efficiency/vapor pressure deficit calculations have been modified so that the RUE value defined by BIO_E in crop.dat is used when the vapor pressure deficit is $\leq$ 1.0 kPa. Set a lower limit on RUE reduction caused by high vapor pressure deficit. The lower limit is $0.27 \cdot$BIO_E. These changes make SWAT comparable with ALMANAC RUE/VPD calculations.
37) ***3/5/2001 update:*** Model modified to allow an unlimited number of different pesticides to be applied and modeled in HRUs. (only one pesticide routed)
38) ***3/5/2001 update:*** Edge of field filter/buffer strip processes incorporated.
39) ***4/18/2001 update:*** Reviewed pesticide algorithms and corrected.
40) ***7/12/2001 update:*** Number of soil layers was not set properly when 10 layers of data were in profile. Corrected.
41) ***7/12/2001 update:*** Model assumed that items in database files (crop.dat, fert.dat, pest.dat, till.dat, urban.dat) were numbered consecutively from top to bottom. Modified so that number listed at front of line is the id number used by the model.
42) ***8/31/2001 update:*** Relative humidity value calculated or read in only for Penman-Montieth or Priestley-Taylor PET methods, but value is needed

irregardless of PET method (used in vapor pressure deficit calculation in plant growth). Changed code to always define relative humidity.

Input changes: all input files have been changed

1) Watershed configuration file (.fig)
   a) Eliminated ROUTSUB command.
   b) Made ROUTRES command into a 2-line command with the name of the reservoir file (.res) and lake water quality file (.lwq) entered on the second line. These file names were formerly listed in file.cio. Moving the file names allows more than 6 reservoirs (the limit in previous versions) to be modeled in a SWAT run. Up to 1000 routres commands may be listed in a .fig file.
   c) TRANSFER command no longer applies water to a subbasin. It can still be used to move water between different reaches and reservoirs. Water applied to a subbasin is handled in the management file.
   d) Previous versions of the model required one **subbasin** command line for every HRU modeled. SWAT2000 requires one **subbasin** command line for every subbasin modeled. The number of HRUs and their input files are now listed in the .sub file.
   e) Reach number is now the same as the subbasin number.
   f) New command: SAVECONC. This command writes daily flow and concentration data for a specific point on the channel network (i.e. a specific hydrograph node) to a specified output file. This command is a very good way to isolate flow and concentration information for comparison to measured records.
   g) New command: STRUCTU. This command simulates aeration of water in the main channel due to turbulence caused by passing over a weir or other man-made structures along the channel.
2) File.cio
   a) Eliminated variables STATIN, WQOUT
   b) ***2/1/2001 update:*** eliminated variable LWQOUT
   c) Eliminated variable STDOUT. The standard output file names are now always set to "output.std" and "input.std".
   d) Moved variables RESVO and LWQDAT to .fig
   e) New variables: FERTDAT, URBDAT, NSTOT, NHTOT, NWTOT, SLRFILE, RHFILE, WNDFILE, PETFILE, WTROUT
   f) List files for every subbasin instead of every HRU
3) Project.alo input file eliminated. Array dimensions now calculated within model.
4) Input control code file (.cod)
   a) Eliminated variables: IWST, ISST, IRTSUB, IPDWQL and IOPT
   b) New variables: SLRSIM, RHSIM, WNDSIM, IWQ, ICRK, IRTE
   c) IPET has new option: 3-read in daily PET values
   d) IDIST and REXP moved from .wgn file to .cod file
   e) IHUMUS replaced with ISPROJ

5) General watershed file (.bsn)
   a) New variables: CMN, EVRCH, EVLAI, RBO_A, RBO_B, RBO_A1, RBO_B1, PET_ALPHA, PSP, MSK_CO1, MSK_CO2, MSK_X
   b) ***2/1/2001 update:*** removed variables RBO_A, RBO_B, RBO_A1, RBO_B1, PET_ALPHA,
   c) Variable BIOMIX made into HRU variable and moved to .mgt file
   d) Variable ANION_PORE made into HRU variable and moved to .sol file
6) Weather generator file (.wgn):
   a) Replaced coefficient of variation for average daily temperature with standard deviation for max and min temperature.
   b) Eliminated need for 10-yr frequency 0.5 h and 6.0 h rainfall (RAIN_HH and RAIN_6H). These were used to calculate a coefficient used to determine the peak rate. The peak rate calculations now mirror those in EPIC.
   c) PCP_STAT(mon,1,:) replaced with PCP_MM(mon). PCP_STAT(mon,1,:) is the rain in mm during the month divided by the number of days in the month that rain is falling. PCP_MM(mon) is the rain in mm during the month.
   d) Units for SOLAR_AV have changed from langleys to MJ/m^2.
   e) Variables IDIST and REXP made into watershed level variables and moved to .cod file--no longer in .wgn file.
7) .pcp and .tmp files:
   a) Header lines added to measured precipitation and temperature files that list latitude, longitude and elevation for gages. Latitude and longitude are not used by the model, but elevation is used to adjust precipitation and temperature when elevation bands are present.
   b) Model will read sub-daily precipitation (for defined intervals-no breakpoint) when modeling Green & Ampt infiltration.
8) New climate input files: .slr,.hmd,.wnd,.pet. These files allow measured data or data generated with a different weather generator to be used by the model.
9) Subbasin general input file (.sub):
   a) Variables moved from .sub to .hru: HRU_FR, OV_N, LAT_TTIME, LAT_SED, SLSUBBSN, SLOPE, RSDIN, SLSOIL, ESCO, EPCO, CANMX, FILTERW, IURBAN, URBLU
   b) New variables: HRUTOT
   c) HRU file names (.hru, .mgt, .sol, .chm, .gw) listed at end of .sub instead of in file.cio
   d) Variables added to .sub: LATITUDE, ELEV. Formerly the latitude and elevation in .wgn were used for the subbasin latitude, however the values in .wgn belong to the weather station and may be different from the proper values for the subbasin. If the user doesn't input the latitude and elevation in the .sub file, the latitude and elevation in the .wgn file is used.
10) New input file: HRU general input file (.hru):
   a) Variables moved from .sub to .hru: HRU_FR, OV_N, LAT_TTIME, LAT_SED, SLSUBBSN, SLOPE, RSDIN, SLSOIL, ESCO, EPCO, CANMX, FILTERW, IURBAN, URBLU

b) Variables moved from .mgt to .hru: IRR, IRRNO, FLOWMIN, DIVMAX, DDRAIN, TDRAIN, GDRAIN, NPTOT
c) New variables: ERORGN, ERORGP, IPOT, POT_FR, POT_TILE, POT_VOLX, POT_VOL, POT_NSED, POT_NO3L, FLOWFR
d) ***3/5/2001 update:*** NPTOT (number of pesticides used in HRU) now calculated by the model. This variable no longer needed.

11) Soil input file (.sol):
a) ANION_EXCL moved from .bsn to .sol
b) New variable: HYDGRP
c) Deleted line containing dry soil albedo data. This data was never used by the model.
d) Variable moved from .sol to .chm: SOL_NO3

12) Soil chemical file (.chm):
a) Variable moved from .sol to .chm: SOL_NO3
b) Allow data for SOL_ORGN, SOL_ORGP, SOL_LABP to be entered for all soil layers instead of one value for soil profile.
c) SOL_PST units have changed from kg/ha to mg/kg
d) New variable: PSTNUM (pesticide number)

13) Management file (.mgt):
a) Variables moved from 2nd line of .mgt to .hru: IRR, IRRNO, FLOWMIN, DIVMAX, DDRAIN, TDRAIN, GDRAIN, NPTOT
b) Variable moved from .bsn to .mgt: BIOMIX
c) New variable: HARVEFF added to Harvest Only operation
d) New operation: Release/impound water (for rice) operation #13
e) ***2/1/2001 update:*** Removed variables FRMINN, FRMINP, FRORGN, FRORGP, and FRNH3N from fertilizer operation. These variables were relicts from the time that SWAT did not have a fertilizer database file.

14) Water use file (.wus): reformat

15) Groundwater file (.gw):
a) New variables: GWNO3, GWSOLP

16) Main channel file (.rte):
a) Variables moved from .rte to .swq: CHPST_CONC, CHPST_REA, CHPST_VOL, CHPST_KOC, CHPST_STL, CHPST_RSP, CHPST_MIX, SEDPST_CONC, SEDPST_REA, SEDPST_BRY, SEDPST_ACT
b) New variable: ALPHA_BNK

17) Reservoir file (.res):
a) RESOUT data stored in separate file.
b) New variable: RESMONO (name of file containing RESOUT data)

18) Pond file (.pnd): reformat

19) Watershed water quality file (.wwq): reformat

20) Stream water quality file (.swq):
a) Variables moved from .rte to .swq: CHPST_CONC, CHPST_REA, CHPST_VOL, CHPST_KOC, CHPST_STL, CHPST_RSP, CHPST_MIX, SEDPST_CONC, SEDPST_REA, SEDPST_BRY, SEDPST_ACT
b) Eliminated variable: WTEMP

21) Lake water quality file (.lwq): reformat

22) Plant growth database (crop.dat):
    a) Removed all data not used by SWAT
    b) Split DPL1 into FRGRW1 & LAIMX1; split DPL2 into FRGRW2 & LAIMX2; split PT2 into CO2HI & BIOEHI
    c) New variable: RSDCO_PL
    d) ***2/1/2001 update:*** split VPD2 into VPDFR & FRGMAX
    e) ***2/1/2001 update:*** eliminated variable VPTH
23) Fertilizer database (fert.dat):
    a) New variable: IFNUM
24) Pesticide database (pest.dat): reformat