V.3.3-SWB-NILE SIMPLE WATER BALANCE MODEL OPERATION

Identifier: SWB-NILE

Application: All programs

Description: This Operation is based on the Water Balance component of the Nile Forecast System developed by the Technology Transfer Center of the NWS Office of Hydrology. A detailed discussion of the water balance model (known as the Simple Water Balance model or SWB) is given in a paper 'Simple Water Balance Model for Estimating Runoff at Different Spatial and Temporal Scales' [Schaake et al., 1996].

The following provisions, in addition to the basic component of SWB, are included in this Operation:

1. A precipitation multiplying factor is provided for possible use during operational program run. This precipitation multiplier is only applied during the computational period (i.e., period with observed data).

2. The ET-demand can be uniform throughout the day or can have a fixed diurnal variation. The fixed diurnal ET-demand variation expressed as percent/100 of daily ET-demand that is applied each hour is:

Hour (local time)	Portion of ET-demand
1-8	0.00
9	0.02
10	0.05
11	0.10
12	0.16
13	0.20
14	0.18
15	0.14
16	0.09
17	0.05
18	0.01
19-24	0.00

Allowable Data Time Intervals: 1, 2, 3, 4, 6, 8, 12 and 24 hours

Time Series Used: Time series used in this Operation are as follows:

General Type	Dimn	Units	Use	Required	Form of Output T.S.	Data Time Interval	Missing Values Allowed
Precipitation (rain+melt)	L	MM	I	yes	n/a	any	no

General Type	Dimn	Units	Use	Required	Form of Output T.S.	Data Time Interval	Missing Values Allowed
Total Runoff	L	MM	O	no	replaces	any 1/	no
Potential Evaporation	L	MM	I	no	n/a	any	no
Surface Runoff	L	MM	O	no	replaces	any 1/	no
Groundwater Runoff	L	MM	O	no	replaces	any 1/	no
Soil Moisture Contents 2/	L	3/	O	no	replaces	any 1/	no
Air Temperature	TEMP	DEGC	I	yes 3/	n/a	any	no
Precipitation (rain+snowfall)	L	MM	I	yes 3/	n/a	any	no
Water-Equivalent	L	MM	I	yes 3/	n/a	any	no
Frost Efficiency Index 4/	DLES	PCTD	O	no	replaces	any 1/	no
Observed Snowfall	L	MM	I	no	n/a	any	no

1/ Must by an even multiple of the data time interval for precipitation.

2/ The first two elements in soil moisture time series are soil moisture deficit in upper and lower layers. The third element is the total frozen soil depth. The fourth element is the total ice content. The fifth element is the snow depth.

3/ The units for the first two and the fourth elements in soil moisture time series are in MM. The third and fifth elements are in CM.

4/ Required only if frozen ground option is activated.

Input Summary: The card input for this Operation is as follows:

Card	Format	Columns	Contents
1	5A4	1-20	Description of area or runoff zone
	3X,I2	24-25	Time interval for precipitation and total runoff time series
	7X,2A4	33-40	Identifier of precipitation or rain+melt time series
	1X,A4	42-45	Precipitation or rain+melt data type

Card	Format	Columns	Contents
			code
	7X,2A4	53-60	Identifier of total runoff time series (leave blank if total runoff time series is not needed)
	1X,A4	62-65	Total runoff time data type code (leave blank if not needed)
2	1X,A4	2-5	Surface runoff data type code
	1X,A4	7-10	Groundwater runoff data type code
	1X,A4	12-15	Soil moisture data type code
	1X,A4	17-20	Enter 'FRZE' to use the frozen ground option (blank otherwise)
	1X,A4	22-25	Air temperature data type code
	1X,A4	27-30	Rain+snowfall data type code
	1X,A4	32-35	Snow water-equivalent data type code
	1X,A4	37-40	Frost Efficiency Index data type code
	1X,A4	42-45	Observed snowfall data type code
	1X,A4	47-50	Enter 'PROT' to display detailed output for each time interval (Blank otherwise). For calibration, the months to print are controlled by card 10)
	4X,I1	55	Control to store water balance sums: 0 = do not store sums 1 = store sums
3	2X,2A4	3-10	Identifier for potential ET time series (blank if not used)
	1X,A4	12-15	Potential ET data type code (blank if not used)
	5X,12F5.2	21-80	ET-demand or PE-adjustment factor for the 16th of each month (January-December). Daily values are computed by linear interpolation. If PE data are used, then value PE-adjustment. Otherwise the values represent ET-demand.
4	F5.2	1-5	PXADJ (precipitation adjustment factor) - CAUTION: this factor may have been applied in a preceding snow model

Card	Format	Columns	Contents
			Operation
	F5.2	6-10	PEADJ (ET-demand adjustment factor)
	F5.0	11-15	DMAX (maximum soil moisture storage capacity in lower layer, MM)
	F5.2	15-20	KG (potential groundwater runoff, MM/DAY)
	F5.3	21-25	ALPSM (fraction of lower layer which produces groundwater runoff, decimal fraction)
	F5.3	26-30	ALPRT (maximum soil moisture storage capacity in upper layer expressed as a fraction of DMAX, decimal fraction)
	F5.2	31-35	KDT (time scale parameter controlling infiltration process, 1/day)
	4X,I1	40	Diurnal ET variation option - default is uniform distribution of daily ET-demand. Enter value greater than zero to used diurnal variation (see Table 1 for variation pattern).

Card 5 is needed if surface runoff, groundwater runoff or soil moisture time series are generated.

5	2X,2A4	3-10	Identifier of surface runoff time series
	2X,2A4	13-20	Identifier of groundwater runoff time series
	2X,2A4	23-30	Identifier of soil moisture time series
	3X,I2	34-35	Time interval of soil moisture time series

Cards 6 and 7 are needed only if frozen ground model option is specified ('FRZE' is entered in columns 17-20 of Card 2).

6	2X,2A4	3-10	Identifier of air temperature time series
	3X,I2	14-15	Time interval of air temperature time series
	2X,2A4	18-25	Identifier of precipitation (rain+snowfall) time series
	3X,I2	29-30	Time interval of rain+snowfall time series

Card	Format	Columns	Contents
	2X,2A4	33-40	Identifier of snow water-equivalent time series
	3X,I2	44-45	Time interval of snow water-equivalent time series
	2X,2A4	48-55	Identifier of frost efficiency index time series (blank if not used)
	3X,I2	59-60	Time interval of frost efficiency index time series (blank if not used)
	2X,2A4	63-70	Identifier of observed snowfall time series (blank if not used)
	3X,I2	74-75	Time interval of observed snowfall time series (blank if not used)
7	F5.1	1-5	KIMP (parameter of impermeable frozen soil, no unit)
	F5.2	6-10	DSOIL (soil density, G/CM3)
	F5.3	11-15	POROS (soil porosity, decimal fraction)
	F5.3	16-20	WWP (wilting point volumetric soil moisture, decimal fraction)
	F5.1	21-25	CVICE (coefficient of variation of ice content distribution)
8	F5.1	1-5	SU (upper layer soil moisture, MM)
	F5.1	6-10	SB (lower layer soil moisture, MM)

Card 9 is needed only if frozen ground model option is specified ('FRZE' is entered in columns 17-20 of Card 2).

9	F5.1	1-5	FDP(1) (frozen depth in upper layer, CM)
	F5.1	6-10	FDP(2) (frozen depth in lower layer, CM)
	F5.1	11-15	TDP(2) (thawing depth in upper layer, CM)
	F5.1	16-20	TDP(2) (thawing depth in lower layer, CM)
	F5.1	21-25	SDP (snow depth, CM)
	F5.2	6-10	SDN (snow density, G/CM3)

Card 10 is needed only if this is a calibration program and detailed output is requested ('PROT' is entered in columns 47-50

Card	Format	Columns	Contents
of Card 2).			
10			The first four fields specify the first period for which detailed output is to be printed. The second and third four fields are for the second and third periods for which detailed output is to printed.
	3X,I2	4-5	Beginning month
	1X,I4	6-10	Beginning year (4 digits)
	3X,I2	14-15	Ending month
	1X,I4	16-20	Ending year (4 digits)
		24-40	Same information for second period of detailed output (same format - leave blank is not used)
		44-60	Third period of detailed output

Printed Output: During execution, this Operation contains the option to print detailed output for each computational time interval. This output consists of the state variables and other computed quantities. This output is quite voluminous and should only be requested when really is needed. In the Manual Calibration Program (MCP3), detailed output can be obtained for selected periods specified by the user.

Error and Warning Messages: The error and warning messages generated by this Operation and the corrective action to take when they occur are as follows:

A. Messages that can occur during setup.

1. **ERROR** THE TIME INTERVAL(XX HOURS) FOR TYPE XXXX IS NOT A MULTIPLE OF THE TIME INTERVAL(YY HOURS) FOR TYPE YYYY.

   Action: Specify correct time interval for the selected data type.

2. **ERROR** ONE OR MORE TIME SERIES USED IN FROZEN GROUND ARE NOT DEFINED

   Action: Define air temperature, rain+snowfall and snow water-equivalent time series to be used in frozen ground model.

3. **WARNING** X UNREASONABLE PARAMETER VALUES DETECTED AND THEIR VALUES HAVE BEEN CHANGED

   Action: Check all parameter values to make sure they are reasonable.

4. **WARNING** INITIAL STATE VARIABLES CONTAIN IMPOSSIBLE VALUES.

Action: Check all soil moisture initial carryover values to make sure they are reasonable.

5. **WARNING** INITIAL FROZEN GROUND STATE VARIABLES CONTAIN IMPOSSIBLE VALUES.

   Action: Check all frozen ground initial carryover variables to make sure they are reasonable.

B. Message during execution: None.

Carryover Transfer Rules: The following rules apply to the state variables during carryover transfer process:

1. SU - value is retained as long as it does not exceed DMAX*ALPSM. If SU does exceed DMAX*ALPSM, then the new carryover is equal to (DMAXO*ALPSMO)/(DMAX*ALPSM)*SUO.

2. SB - value is retained as long as it does not exceed DMAX. If SB does exceed DMAX, then the new carryover is equal to DMAXO/DMAX*SUO.

3. Frozen ground carryover variables are not changed.

Punch Card Limitation: The punch card formats for this Operation are:

Parameter or Variable	Punch Format	Maximum Value	Precision After Decimal Point
DMAX	F5.0	9999.	none
SU,SB,FDP(1),FDP(2), TDP(1),TDP(2),SDP, WICE(1),WICE(2),KIMP,CVICE	F5.1	999.9	tenths
PXADJ,PEADJ,KG,KDT, DSOIL,SDN	F5.2	99.99	hundredths
ET-demand curve or PE adjustment factor curve	F5.2	99.99	hundredths
ALPSM,ALPRT,POROS,WWP	F5.3	9.999	thousandths

References:

Schaake, J.C.,Jr., V.I. Koren, Q.Y. Duan, K. Mitchell and F. Chen, 'Simple Water Balance Model for Estimating Runoff at Different Spatial and Temporal Scales', Journal of Geophysical Research, Volume 101, March 20, 1996.