

V.3.3-XIN-SMA XINANJIANG SOIL MOISTURE ACCOUNTING OPERATION

Identifier: XIN-SMA

Application: All programs

Description: This Operation is based on the soil moisture accounting portion of the Xinanjiang model (R.J.Zhao et al, China, 1974).

A complete description of this Operation is in Chapter II.3-XIN-SMA.

The special provisions of this Operation include the following:

1. The XIN-SMA Operation is designed to perform soil moisture accounting for up to 25 sub-basins with the same set of parameters. If users want to use more than 25 sub-basins or more than one set of parameters in a watershed, additional XIN-SMA Operations should be used.
2. The ET-demand can be uniform throughout the day or can have a fixed diurnal variation. The diurnal ET-demand variation expressed as percent/100 of daily ET-demand that is applied each hour is as follows:

<u>Hour (local time)</u>	<u>Portion of ET-demand</u>
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

References: R. J. Zhao, et al, 'The Flood Forecast Methods Applied in Humid Areas of China', Department of Hydrology, River and Ocean University, Nanjing, China.

R. J. Zhao, 1984, 'Xinanjiang Model Applied in China', East China Technical University of Water Resources, Nanjing, China.

Developed by: Qingping Zhu, Yellow River Conservancy Commission, China

Allowable 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 <u>1/</u>	L	MM	I	yes	n/a	any	no
Channel inflow <u>1/</u>	L	MM	O	yes	replaces	any <u>2/</u>	no
Potential ET	L	MM	I	no	n/a	24	no

1/ Multiple time series are allowed but all must be for the same time interval.

2/ Must be the same as the time interval for precipitation data.

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

Card	Format	Columns	Contents
1	5A4	1-20	General user supplied heading information
	3X,I2	24-25	Number of sub-basins (maximum of 25)
	3X,I2	29-30	Data time interval of precipitation and channel inflow data
	10X,A4	41-44	Detail soil moisture and components of channel inflow print-out option; default is no detailed output; enter 'PRST' to get detailed printer output; in Calibration System program MCP3 program detailed output is printed only for selected months
	1X,A4	46-49	Option only used in Calibration System programs to print monthly sums of water balance, runoff and channel inflow components; default is no sums printed; enter 'SUMS' if sums are to be printed
2	F5.2	1- 5	K (evapotranspiration adjustment)
	F5.2	6-10	IMP (portion of impervious area; units of percent/100)
	F5.0	11-15	WUM (upper zone tension water capacity; units of MM)
	F5.0	16-20	WLM (lower zone tension water capacity; units of MM)
	F5.0	21-25	WDM (deep zone tension water capacity;

<u>Card</u>	<u>Format</u>	<u>Columns</u>	<u>Contents</u>
			units of MM)
	F5.0	26-30	SM (free water capacity; units of MM)
	F5.1	31-35	B (exponent of the tension water capacity curve)
	F5.1	36-40	EX (exponent of the free water capacity curve)
	F5.2	41-45	C (coefficient of deep evapotranspiration; units of percent/100)
	F5.2	46-50	KSS (daily interflow output coefficient)
	F5.2	51-55	KG (daily groundwater output coefficient)
			KSS + KG must be \leq 1.0
	F5.2	56-60	CI (daily recession coefficient for interflow runoff)
	F5.3	61-65	CG (daily recession coefficient for groundwater runoff)
	4X,I1	70	Diurnal (ET variation option-default is uniform distribution of daily ET-demand); enter '1' to use diurnal variation
3	2X,2A4	3-10	Identifier for potential ET time series (blank if none used)
	1X,A4	12-15	Data type code for potential ET time series (blank if none used)
	5X,12F4.2	21-68	ET-demand (MM/day) or PE-adjustment factor for the 16th of each month (January-December); daily values are computed by linear interpolation; if PE data used then values are PE adjustments; if PE data not used then values represent ET demand
Repeat card 4 for each sub-basin.			
4	2X,2A4	3-10	Identifier for precipitation time series of the sub-basin
	1X,A4	12-15	Data type code-precipitation time series
	5X,2A4	21-28	Identifier for channel inflow time

series of the sub-basin

1X,A4 30-33 Data type code-channel inflow time series

Repeat card 5 for each sub-basin.

5 Initial carryover values for the state variables:

F5.1	1-5	WUC (upper zone tension water content; units of MM)
F5.1	6-10	WLC (lower zone tension water content; units of MM)
F5.1	11-15	WDC (deep zone tension water content; units of MM)
F5.1	16-20	SC (free water content; units of MM)
F5.2	21-25	QIC (interflow inflow; units of MM)
F5.2	26-30	QGC (groundwater inflow; units of MM)
F5.3	31-35	FRC (runoff area; units of percent/100)

Card 6 only needed if this is a Calibration System program (MCP3 or OPT3) and detailed output was requested on card 1.

6 14I5 1-70 Months for which detailed output is needed; form of input is month, year, month, year, etc.; years are 4 digits; months must be in chronological order; maximum of 7 months can be entered

Sample Input and Output: Sample input is shown in Figure 1. Sample output from the parameter print routine is shown in Figure 2. Sample execution routine output is shown in Figure 3.

During execution this Operation contains two options. The first is to print detailed soil moisture output for each computational time interval. This output consists of each state variable at the end of the interval and runoff and channel inflow components for the interval. This output is quite voluminous and, therefore, should only be requested when it is really needed. When this Operation is used in Calibration System programs MCP3 or OPT3 and the detailed output option is selected, the output is generated just for selected months. The second is to print the sums of the water balance, runoff and channel inflow components for each month and the total run period. This option is only used in the Calibration System programs.

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**** NUMBER OF SUB-BASINS=XX. ONLY NUMBERS FROM 1 TO 25 ARE ALLOWED.

Action: Use an allowable number. When more than 25 basins are really needed, use another XIN-SMA Operation for the remaining sub-basins.

2. ****ERROR**** TIME INTERVAL=XX, ONLY INTERVALS OF 1,2,3,4,6,8,12 AND 24 HOURS ARE ALLOWED.

Action: Use an allowable computation time interval.

3. ****WARNING**** XX PARAMETERS WERE CHANGED BECAUSE THEY WERE ASSIGNED IMPOSSIBLE VALUES.

Action: Check that revised values are okay.

B. Messages that can occur during setup or execution.

1. ****WARNING**** INITIAL STATE VARIABLES FOR UNIT XX CONTAIN IMPOSSIBLE VALUES

	WUC	WLC	WDC	SC	QIC	QGC
FRC						
INITIAL VALUES WERE	XXX	XXX	XXX	XXX	XXX	XXX
XXX						
CHANGED TO	XXX	XXX	XXX	XXX	XXX	XXX
XXX						

Action: Check the revised values.

C. Messages that can occur during execution.

1. ****WARNING**** WATER BALANCE RESIDUAL EXCEEDS 1 MM. RESIDUAL=XXX.XX FOR UNIT XX.

Action: Operation is not executing properly; call for assistance.

2. ****WARNING**** TENSION WATER WAS DRIED UP DURING XX/XXXX.

Action: Parameters or initial state variables are not assigned proper values; misleading results may be produced. User should adjust parameters or initial state variables, such as reduce K or C or increase WDM or initial tension water contents.

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

1. WUC, WLC, WDC, SC - the ratio (i.e., content/capacity) are retained

2. QIC, QGC, FRC - values remain the same
3. If the number of sub-basins is enlarged, carryover values for the additional sub-basins are average values for the old sub-basins.

Punch Card Limitations: The punched card formats for this Operation are as follows. No checks are made to determine if quantities exceed the maximum allowable value.

<u>Parameters or Variables</u>	<u>Punch Format</u>	<u>Maximum Value</u>	<u>Precision after Decimal Point</u>
WUM, WLM WDM, SM	F5.0	9999.	none
WUC, WLC WDC, SC	F5.1	999.9	tenths
B, EX QIC, QGC	F5.2	99.99	hundredths
IMP, C KSS, KG CI, CG FRC	F5.3	0.999	thousandths
K PE adjustment curve	F4.2	9.99	hundredths
ET demand curve	F4.1	99.9	tenths

Figure 1. Sample Card Input For Operation XIN-SMA

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- Column -
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80
-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
XIN-SMA      HATSW
HATTIESBURG LOCAL      2      6
.95 .005 35. 75. 90. 20. 0.6 0.4 .15 .35 .25 .70 .990
PWA      MAPE      0.9 .85 .85 .85 1.1 1.71.471.351.271.211.15 1.1
HATSWU      MAP      HATSWU      INFW
HATSWL      MAP      HATSWL      INFW
25. 90. 75. 5.0 1.0 0.16
25. 90. 75. 5.0 1.0 0.16

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Figure 2. Sample Output From Operation XIN-SMA Print Parameter Routine

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*****
XIN-SMA OPERATION      NAME=HATSW      PREVIOUS NAME=
*****

XINANJIANG BASIN MODEL OPERATION FOR HATTIESBURG LOCAL

COMPUTATIONAL TIME INTERVAL IS 6 HOURS.

THE NUMBER OF UNITS IS 2.

TIME SERIES USED BY THIS OPERATION.

CONTENTS      I.D.      TYPE      TIME INTERVAL
POTENTIAL ET      PWA      MAPE      24 HOURS
RAIN+MELT FOR UNIT 1 HATSWU      MAP      6 HOURS
INFLOW FOR UNIT 1 HATSWU      INFW      6 HOURS
RAIN+MELT FOR UNIT 2 HATSWL      MAP      6 HOURS
INFLOW FOR UNIT 2 HATSWL      INFW      6 HOURS

PARAMETER VALUES - CAPACITIES ARE IN MM.

K      IMP      WUM      WLM      WDM      SM      B      EX      C      KSS      KG      CI      CG
0.95  0.00  35.  75.  90.  20.  0.6  0.4  0.15  0.35  0.25  0.70  0.990

16TH OF MONTH VALUES      1      2      3      4      5      6      7      8      9      10     11     12
PE-ADJUSTMENT      0.90  0.85  0.85  0.85  1.10  1.70  1.47  1.35  1.27  1.21  1.15  1.10

DAILY ET DISTRIBUTION IS UNIFORM.

SOIL-MOISTURE AND DISCHARGE CONTENTS FOR HATTIESBURG LOCAL

UNIT      WUC      WLC      WDC      SC      QIC      QGC      FRC
1      25.0  75.0  75.0  5.0  1.00  0.16  0.00
2      25.0  75.0  75.0  5.0  1.00  0.16  0.00

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Figure 3. Sample Output From Operation XIN-SMA Execution Routine

UNIT	DAY	HR	RAIN	ET-DM	ACT-E	RUNOFF	RS	RSS	RG	CIN	QIC	QGC	WC	WUC	WLC	WDC	SC	FRC
1	29	11	0.0	0.3	0.3	0.0	0.0	0.0	0.0	1.07	0.91	0.16	174.7	24.7	75.0	75.0	4.0	0.00
2	29	11	0.0	0.3	0.3	0.0	0.0	0.0	0.0	1.07	0.91	0.16	174.7	24.7	75.0	75.0	4.0	0.00
1	29	17	0.0	0.3	0.3	0.0	0.0	0.0	0.0	1.00	0.84	0.16	174.3	24.3	75.0	75.0	3.2	0.00
2	29	17	0.0	0.3	0.3	0.0	0.0	0.0	0.0	1.00	0.84	0.16	174.3	24.3	75.0	75.0	3.2	0.00
1	29	23	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.92	0.77	0.16	174.0	24.0	75.0	75.0	2.5	0.00
2	29	23	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.92	0.77	0.16	174.0	24.0	75.0	75.0	2.5	0.00
1	30	5	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.86	0.70	0.16	173.7	23.7	75.0	75.0	2.0	0.00
2	30	5	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.86	0.70	0.16	173.7	23.7	75.0	75.0	2.0	0.00
1	30	11	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.80	0.64	0.16	173.4	23.4	75.0	75.0	1.6	0.00
2	30	11	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.80	0.64	0.16	173.4	23.4	75.0	75.0	1.6	0.00
1	30	17	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.74	0.59	0.16	173.2	23.2	75.0	75.0	1.3	0.00
2	30	17	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.74	0.59	0.16	173.2	23.2	75.0	75.0	1.3	0.00
1	30	23	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.69	0.54	0.16	172.9	22.9	75.0	75.0	1.0	0.00
2	30	23	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.69	0.54	0.16	172.9	22.9	75.0	75.0	1.0	0.00
1	31	5	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.65	0.49	0.16	172.7	22.7	75.0	75.0	0.8	0.00
2	31	5	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.65	0.49	0.16	172.7	22.7	75.0	75.0	0.8	0.00
1	31	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.60	0.45	0.16	172.6	22.6	75.0	75.0	0.6	0.00
2	31	11	2.3	0.0	0.0	1.2	0.0	0.1	0.1	0.65	0.46	0.16	173.7	23.7	75.0	75.0	1.7	0.53
1	31	17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.57	0.41	0.16	172.6	22.6	75.0	75.0	0.5	0.00
2	31	17	19.8	0.0	0.0	11.2	2.1	0.8	0.6	2.78	0.49	0.16	182.3	32.3	75.0	75.0	15.2	0.56
1	31	23	25.4	0.0	0.0	14.4	3.1	0.9	0.6	3.74	0.45	0.16	183.6	33.6	75.0	75.0	17.4	0.56
2	31	23	45.2	0.0	0.0	30.9	23.2	1.7	1.2	23.99	0.60	0.16	196.5	35.0	75.0	86.5	19.5	0.68
1	1	5	38.7	0.0	0.0	26.4	20.0	1.8	1.3	20.76	0.56	0.16	195.8	35.0	75.0	85.8	19.4	0.68
2	1	5	28.2	0.0	0.0	24.6	17.3	2.2	1.6	18.22	0.74	0.16	200.0	35.0	75.0	90.0	19.3	0.87
1	1	11	0.0	0.2	0.2	0.0	0.0	1.6	1.1	0.81	0.65	0.16	195.6	34.8	75.0	85.8	15.5	0.68
2	1	11	0.0	0.2	0.2	0.0	0.0	2.0	1.4	1.01	0.85	0.17	199.8	34.8	75.0	90.0	15.3	0.87
1	1	17	0.0	0.2	0.2	0.0	0.0	1.3	0.9	0.86	0.70	0.16	195.4	34.6	75.0	85.8	12.3	0.68
2	1	17	0.0	0.2	0.2	0.0	0.0	1.6	1.1	1.08	0.91	0.17	199.6	34.6	75.0	90.0	12.2	0.87
1	1	23	0.0	0.2	0.2	0.0	0.0	1.0	0.7	0.89	0.72	0.17	195.1	34.4	75.0	85.8	9.8	0.68
2	1	23	0.0	0.2	0.2	0.0	0.0	1.3	0.9	1.11	0.94	0.17	199.4	34.4	75.0	90.0	9.7	0.87
1	2	5	0.0	0.2	0.2	0.0	0.0	0.8	0.6	0.90	0.73	0.17	194.9	34.1	75.0	85.8	7.8	0.68
2	2	5	0.0	0.2	0.2	0.0	0.0	1.0	0.7	1.12	0.95	0.17	199.1	34.1	75.0	90.0	7.7	0.87
1	2	11	0.0	0.3	0.3	0.0	0.0	0.6	0.5	0.89	0.72	0.17	194.6	33.8	75.0	85.8	6.2	0.68
2	2	11	0.0	0.3	0.3	0.0	0.0	0.8	0.6	1.11	0.93	0.17	198.8	33.8	75.0	90.0	6.1	0.87
1	2	17	0.0	0.3	0.3	0.0	0.0	0.5	0.4	0.87	0.70	0.17	194.2	33.5	75.0	85.8	4.9	0.68
2	2	17	0.0	0.3	0.3	0.0	0.0	0.6	0.5	1.08	0.91	0.17	198.5	33.5	75.0	90.0	4.9	0.87
1	2	23	0.0	0.3	0.3	0.0	0.0	0.4	0.3	0.84	0.68	0.17	193.9	33.1	75.0	85.8	3.9	0.68
2	2	23	0.0	0.3	0.3	0.0	0.0	0.5	0.4	1.05	0.87	0.18	198.1	33.1	75.0	90.0	3.9	0.87
1	3	5	0.0	0.3	0.3	0.0	0.0	0.3	0.2	0.81	0.65	0.17	193.6	32.8	75.0	85.8	3.1	0.68
2	3	5	0.0	0.3	0.3	0.0	0.0	0.4	0.3	1.01	0.83	0.18	197.8	32.8	75.0	90.0	3.1	0.87
1	3	11	0.0	0.5	0.5	0.0	0.0	0.3	0.2	0.78	0.61	0.17	193.1	32.3	75.0	85.8	2.5	0.68
2	3	11	0.0	0.5	0.5	0.0	0.0	0.3	0.2	0.97	0.79	0.18	197.3	32.3	75.0	90.0	2.4	0.87
1	3	17	0.0	0.5	0.5	0.0	0.0	0.2	0.1	0.75	0.58	0.17	192.6	31.8	75.0	85.8	2.0	0.68
2	3	17	0.0	0.5	0.5	0.0	0.0	0.3	0.2	0.92	0.74	0.18	196.8	31.8	75.0	90.0	1.9	0.87
1	3	23	0.0	0.5	0.5	0.0	0.0	0.2	0.1	0.71	0.54	0.17	192.1	31.3	75.0	85.8	1.6	0.68
2	3	23	0.0	0.5	0.5	0.0	0.0	0.2	0.1	0.87	0.70	0.18	196.3	31.3	75.0	90.0	1.5	0.87
1	4	5	0.0	0.5	0.5	0.0	0.0	0.1	0.1	0.67	0.51	0.17	191.6	30.9	75.0	85.8	1.2	0.68
2	4	5	0.0	0.5	0.5	0.0	0.0	0.2	0.1	0.83	0.65	0.18	195.9	30.9	75.0	90.0	1.2	0.87
1	4	11	0.0	0.6	0.6	0.0	0.0	0.1	0.1	0.64	0.47	0.17	191.0	30.3	75.0	85.8	1.0	0.68
2	4	11	0.0	0.6	0.6	0.0	0.0	0.1	0.1	0.78	0.61	0.18	195.3	30.3	75.0	90.0	1.0	0.87
1	4	17	0.0	0.6	0.6	0.0	0.0	0.1	0.1	0.61	0.44	0.17	190.4	29.6	75.0	85.8	0.8	0.68
2	4	17	0.0	0.6	0.6	0.0	0.0	0.1	0.1	0.74	0.56	0.17	194.6	29.6	75.0	90.0	0.8	0.87
1	4	23	0.0	0.6	0.6	0.0	0.0	0.1	0.0	0.57	0.41	0.17	189.8	29.0	75.0	85.8	0.6	0.68
2	4	23	0.0	0.6	0.6	0.0	0.0	0.1	0.1	0.70	0.52	0.17	194.0	29.0	75.0	90.0	0.6	0.87
1	5	5	0.0	0.6	0.6	0.0	0.0	0.1	0.0	0.54	0.38	0.17	189.2	28.4	75.0	85.8	0.5	0.68
2	5	5	0.0	0.6	0.6	0.0	0.0	0.1	0.0	0.66	0.48	0.17	193.4	28.4	75.0	90.0	0.5	0.87
1	5	11	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.51	0.35	0.17	188.5	27.7	75.0	85.8	0.4	0.68
2	5	11	0.0	0.7	0.7	0.0	0.0	0.1	0.0	0.62	0.45	0.17	192.7	27.7	75.0	90.0	0.4	0.87
1	5	17	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.49	0.32	0.17	187.8	27.0	75.0	85.8	0.3	0.68
2	5	17	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.59	0.41	0.17	192.0	27.0	75.0	90.0	0.3	0.87
1	5	23	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.46	0.30	0.17	187.0	26.2	75.0	85.8	0.3	0.68
2	5	23	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.55	0.38	0.17	191.2	26.2	75.0	90.0	0.2	0.87
1	6	5	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.44	0.27	0.17	186.3	25.5	75.0	85.8	0.2	0.68
2	6	5	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.52	0.35	0.17	190.5	25.5	75.0	90.0	0.2	0.87
1	6	11	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.41	0.25	0.16	185.5	24.7	75.0	85.8	0.2	0.68
2	6	11	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.49	0.32	0.17	189.7	24.7	75.0	90.0	0.2	0.87
1	6	17	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.39	0.23	0.16	184.8	24.0	75.0	85.8	0.1	0.68
2	6	17	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.47	0.30	0.17	189.0	24.0	75.0	90.0	0.1	0.87
1	6	23	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.38	0.21	0.16	184.0	23.3	75.0	85.8	0.1	0.68
2	6	23	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.44	0.27	0.17	188.3	23.3	75.0	90.0	0.1	0.87
1	7	5	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.36	0.19	0.16	183.3	22.5	75.0	85.8	0.1	0.68
2	7	5	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.42	0.25	0.17	187.5	22.5	75.0	90.0	0.1	0.87