VIII.3.3-SS-SAC STATE SPACE SACRAMENTO MODEL OPERATION

Identifier: SS-SAC

Operation Number: 22

Developed By: Hydrologic Research Center

Parameter Array: The FORTRAN identifier used for the Operation parameter array is P0. Each number stored within P0 represents either a parameter value or else the offset of the storage location of a parameter from a fixed location in the P0 array. This location is the start of storage within P0 of the execution subroutine's local parameter array P. Every parameter variable, array, or offset stored in P0 has a pointer variable associated with it whose content is initialized to its starting location within P0. Each pointer variable name begins with the letter 'P' and is followed by the FORTRAN identifier for the pointer's corresponding parameter.

The following is each Operation parameter or offset, whether it is read from input cards or internally generated by the PIN subroutine, and the name of the pointer variable containing its location within P0:

Pointer	Input Method	Description of Associated Parameter
POPVER	set internally	Version number of the PIN22 used to input parameter set
PILBL	user input	Parameter set label
PMRNO	set internally	Operation reference number
PNCC1	computed	Index of last element used in local parameter array P
PNPA	set internally	Offset into P to where number of soil parameters used is stored
PNQ	computed	Number of Q parameters used
PNR	user input	Number of router parameters used
PALPD	user input	Routing reservoir coefficient parameter
PR1	user input	Discharge constant standard deviation
PR2	user input	Discharge coefficient of variation
PNORG	set internally	Number of soil states of Sacramento model
PTSP	user input	Precipitation time series internal identifier
PTSD	user input	Discharge time series internal identifier
PTSE	user input	ET time series internal identifier
PTSS	user input	Simulated discharge time series internal identifier name
PTSSD	user input	Simulated discharge standard deviation time series internal identifier name
PDTCP	user input	Precipitation data type code
PDTCE	user input	ET data type code

Pointer	Input Method	Description of Associated Parameter
PDTCD	user input	Discharge data type code
PDTCS	user input	Simulated discharge data type code
PDTCSD	user input	Simulated discharge standard deviation data type code
PTSFA	user input	MAP variance modifiers time series data
PDFAC	user input	MPA variance modifiers data type code
PNHST	user input	Computational time interval = time interval between successive precipitation (and discharge) time series data
PNHRSE	user input	ET time series data interval
PNHRSD	set internally	Discharge time series data interval
PPCSD	computed	Offset into P to precipitation constant standard deviation value
PPCV	computed	Offset into P to precipitation coefficient of variation (CV) value
PECSD	computed	Offset into P to ET standard deviation PECV computed offset into P to ET coefficient CV value PSP computed offset into P to where first soil parameter is stored
PRP	computed	Offset into P to where first router parameter is stored
PETSW	user input	Switch to select reading of either ET potential time series correction factors or mean monthly actual demand values
PETDAT	user input	Depending upon ETSW, either 12 monthly correction factors or else 12 monthly actual demand values
PXDIS1	user input	Initial discharge value, CMS
PP	computed	Index of start of local parameter array P in P0 array
PAREA	user input	Catchment area in KM2
PXM	user input	Common exponent parameter of the routing reservoirs
PALP	computed	Common coefficient of routing reservoirs
PQ	computed	Square root of diagonal elements of constant model error covariance matrix
PCFVMX	set internally	Maximum coefficient of variation allowed for statistical linearization (set to zero)
PALINP	user input	Coefficient of input component of model error covariance
PALPAR	user input	Coefficient of parameter component of model error covariance
PPSTDV	user input	Array of standard deviations of model parameter estimates
PSCM	user input	Array of initial soil states
PSCMCV	user input	Array of initial soil land reservoir standard deviations

Order of parameter storage within local parameter array P:

- Number of soil parameters NPA (starting at location P0(PP + INT(P0(PNPA)) - 1), currently set to 18

- NPA Soil Parameter values (starting at location P0(PP + INT(P0(PSP)) - 1):

  1. 1.0
  2. UZTWM
  3. UZFWM
  4. LZTWM
  5. LZFPM
  6. LZFSM
  7. UZK
  8. LZPK
  9. LZSK
  10. ZPERC
  11. REXP
  12. PFREE
  13. SIDE
  14. ADIMP
  15. PCTIM
  16. 8.0
  17. 8.0
  18. 8.0

- NR - number of reservoirs used

- (NR * 2 + 1) Reservoir parameters (starting at location P0(PP) + INT(P0(PRP)) - 1):

  1 = 1.0
  2 to NR = 0.0
  (NR + 1) to (NR * 2) =
ALP
  NR * 2 + 1 = XM

- Coefficient of variation variance parameter of MAP

- Constant standard deviation variance parameter of MAP

- Coefficient of variation variance parameter of ET

- Constant standard deviation variance parameter of ET

- Constant standard deviation variance parameter of discharge

- Coefficient of Variation variance parameter of discharge

- (6+NR) diagonal terms of model error standard deviation

Current parameter pointer contents:

These variables contain the current locations of the various parameters in the P0 array:

PARAMETER (POPVER = 1)
PARAMETER (PILBL = POPVER + 1)

```
   PARAMETER  (PMRNO  =  PILBL   +   15)
   PARAMETER  (PNCC1  =  PMRNO   +   1)
   PARAMETER  (PNR    =  PNCC1   +   1)
   PARAMETER  (PALPD  =  PNR     +   1)
   PARAMETER  (PXM    =  PALPD   +   1)
   PARAMETER  (PALP   =  PXM     +   1)
   PARAMETER  (PSCM   =  PALP    +   6)
   PARAMETER  (PSCMCV =  PSCM    +   6)
   PARAMETER  (PNORG  =  PSCMCV  +   12)
   PARAMETER  (PTSP   =  PNORG   +   1)
   PARAMETER  (PTSD   =  PTSP    +   2)
   PARAMETER  (PTSE   =  PTSD    +   2)
   PARAMETER  (PTSS   =  PTSE    +   2)
   PARAMETER  (PDTCP  =  PTSS    +   2)
   PARAMETER  (PDTCD  =  PDTCP   +   2)
   PARAMETER  (PDTCE  =  PDTCD   +   2)
   PARAMETER  (PDTCS  =  PDTCE   +   2)
   PARAMETER  (PNHST  =  PDTCS   +   2)
   PARAMETER  (PNHRSE =  PNHST   +   1)
   PARAMETER  (PNHRSD =  PNHRSE  +   1)
   PARAMETER  (PAREA  =  PNHRSD  +   1)
   PARAMETER  (PQ     =  PAREA   +   1)
   PARAMETER  (PCFVMX =  PQ      +   12)
   PARAMETER  (PALINP =  PCFVMX  +   1)
   PARAMETER  (PALPAR =  PALINP  +   1)
   PARAMETER  (PPSTDV =  PALPAR  +   1)
   PARAMETER  (PPCSD  =  PPSTDV  +   20)
   PARAMETER  (PPCV   =  PPCSD   +   1)
   PARAMETER  (PECSD  =  PPCV    +   1)
   PARAMETER  (PECV   =  PECSD   +   1)
   PARAMETER  (PR1    =  PECV    +   1)
   PARAMETER  (PR2    =  PR1     +   1)
   PARAMETER  (PDTSD  =  PR2     +   1)
   PARAMETER  (PNDTSD =  PDTSD   +   1)
   PARAMETER  (PNPA   =  PNDTSD  +   1)
   PARAMETER  (PSP    =  PNPA    +   1)
   PARAMETER  (PRP    =  PSP     +   1)
   PARAMETER  (PNQ    =  PRP     +   1)
   PARAMETER  (PETSW  =  PNQ     +   1)
   PARAMETER  (PETDAT =  PETSW   +   1)
   PARAMETER  (PXDIS1 =  PETDAT  +   12)
   PARAMETER  (PSUBS  =  PXDIS1  +   1)
   PARAMETER  (PTSSD  =  PSUBS   +   1)
   PARAMETER  (PDTCSD =  PTSSD   +   2)
   PARAMETER  (PTFSA  =  PDTSCD  +   2)
   PARAMETER  (PDFAC  =  PTFSA   +   2)
   PARAMETER  (PP     =  PDFAC   +   1)
```

Total amount of space in FC parameter array required for Operation:

```
   IUSEP =  PP + NCC1 - 1
         =  (start of local parameter array P in P0) + (size of P) - 1
```

Carryover Array: The FORTRAN identifier used for the carryover array is C0. The contents of the C0 array are:

Position	Contents
	Soil contents state mean values:
1	UZTWC
2	UZFWC
3	LZTWC
4	LZFPC
5	LZFSC
6	ADIMC
	Channel reservoir state mean values:
7	reservoir #1
8	reservoir #2
.	.
.	.
6+NR	reservoir #NR

Upper triangular covariance matrix for (6+NR) rows/columns:
soil states in first six rows and columns, reservoir routers in last NR, in:
(6+NR+1) through (6+NR) + (6+NR) * (6+NR-1)/2

Last initial discharge observed value, CMS

Carryover array pointer definitions:

PARAMETER (PY = 1)

Total storage required by carryover:

IUSEC = (NR+NORGR) + (NR+NORGR) * (NR+NORGR-1)/2 + 1

where NR is the number of reservoirs (max of 6)
NORGR is the number of soil states (always 6)
(Add 1 for initial discharge value)

Maximum storage required by carryover = 91

Subroutines Names and Functions: The subroutines associated with this Operation are:

Subroutine	Function
PIN22	Input cards and stores values in P0 and C0 arrays
IOER22	Handle input file errors
CKSR22	Check for space in P0/C0 and stores real parameter/carryover
CKSI22	Check for space in P0/C0 and stores integer parameter/carryover
PRP22	Print parameter array contents

Subroutine	Function
PRC22	Print carryover array contents
PUC22	Punch contents of P0 array
COX22	Carryover transfer routine
EX22	Execute the Operation
STEP22	Calculate the number of time steps in an interval of time
UPDT22	Update model states from discharge
SYMM22	Check and enforces symmetry of covariance matrix
GMPR22	Compute the product of two matrices
ARAY22	Convert data arrays from single to double dimension
VMFP22	Compute the product of a matrix with the transpose of another matrix (drive routine)
GMTR22	Compute the transpose of a matrix
VMFF22	Compute the product of two matrices (driver routine)
POSD22	Check and enforces positive definiteness for a covariance matrix
CNVR22	Convert a vector to a state vector and its associated covariance matrix
PRED22	Prediction routine
DVR122	Perform integration using a prediction-corrector method
DVRK22	Driver for DVR122
VRPR22	Define the state covariance propagation differential equation
FLWS22	Define the propagation equation
FLWZ22	Define the observation equation
DERU22	Compute derivatives of state equations with respect to input
INTR22	Interpolate 16th of month values to daily values
PRTD22	Print debugging table

Subroutines PIN22, PRP22, PRC22, COX22 and PUC22 have the standard

Subroutine Function

argument lists for these subroutines as given in Section VIII.4.

SUBROUTINE EX22 (P0,C0,DP,DE,DD,DS)

Function: This is the execution subroutine for Operation SS-SAC.

Argument List:

Variable	Input/ Output	Type	Dimension	Description
P0	Input	R*4	Variable	Contains parameters and initial conditions
C0	Input	R*4	Variable	Contains carryover values
DP	Input	R*4	Variable	Contains precipitation time series data values, CM
DE	Input	R*4	Variable	Contains potential ET time series data, MM
DD	Input	R*4	Variable	Contains discharge time series data values, CMS
DS	Output	R*4	Variable	Contains updated discharge values for each compute step and predicted discharge for each forecast step, CMS
DV	Output	R*4	Variable	Contains standard deviation values for the updated discharge for each compute step and standard deviation of predicted discharge for each forecast step, CMS
DF	Input	R*4	Variable	Contains MAP variance modifiers, DLES

Debug Output: During execution this operation contains the options to print, for each computational time interval, one or both of two types of discharge output. The selection of the two types of output can be independently controlled as follows:

1. The output from the first option is a row of values that appears at each interval listing the following parameters:

   observed precipitation (MM/timeint)
   observed ET actual demand (MM/timeint)
   predicted discharge (MM/timeint)
   observed discharge (MM/timeint)
   updated discharge (MM/timeint)

   where timeint is the computational time interval

   This table will be printed when the subroutine FPRBUG returns a

value of 1 for the variable IBUG. The table is not very voluminous and is very useful for debugging.

2. The second type of output can be in one of the following forms by using the HFS1 and HFS2 keyword values with the function IFBUG:

   - o no output at all: when IDB1 = 0 (false)
   - o normal, non-detailed output: when IDB1 = 1 (true) but IDB2 = 0.
   - o very detailed output: when both IDB1 = 1 and IDB2 = 1. This form provides extensive information (including the "normal" output) about the intermediate values of various variables and arrays used in the updating and prediction processes. It is quite voluminous and should be requested with discretion.