VIII.3.3-SNOW-43 NWS-43 SNOW MODEL OPERATION

Identifier: SNOW-43

Operation Number: 31

Developed By: Jay Day, Riverside Technology Inc.

Parameter Array: The FORTRAN identifier used for the parameter array is PS. The contents of the PS array are:

Position	Contents
1	Operation version number (integer value)
2-6	General name for the point or area where the operation is applied
7-8	Identifier of Precipitation time series
9	Data type code of precipitation time series
10	Data time interval of precipitation time series (units of HR)
11-12	Identifier of air temperature time series
13	Data type code of air temperature time series
14	Data time interval of temperature time series (units of HR)
15	Read carryover indicator (integer value): 0 = carryover set to no snow conditions 1 = major initial carryover values input 2 = all initial carryover values input
16	Number of values in PS array (integer value)
17	Location of information on rain plus melt time series in the PS array: 1/ 0 = no rain plus melt time series
18	Location of information on percent snowfall time series in the PS array: 1/ 0 = if no percent snowfall time series
19	Location of information on observed water-equivalent time series in the PS array: 2/ 0 = none used

Position	Contents
20	Location of information on simulated water-equivalent time series in the PS array: 2/ 0 = none used
21	Location of information on observed areal extent of snow cover time series in the PS array: 2/ 0 = none used
22	Location of information on simulated areal extent of snow cover time series in the PS array: 2/ 0 = none used
23	Location of sums of water balance and melt components in the PS array: 3/ 0 = sums not stored
24	Print control (integer value) Daily Printout (ones digit): 0 = no printout 1 = print all days with snow 2 = print only significant days P matrix printing (tens digit): 0 = P matrix not printed 1 = P matrix diagonals printed at daily print interval 2 = Full P matrix printed at daily print interval 3 = Full P matrix printed on first day of month
25	Location of snow model parameters in the PS array 4/
26	Location of areal depletion curve in the PS array 5/
27	Location of temperature parameters in the PS array: 6/ 0 = not needed
28	Location of updating parameters in the PS array: 7/ 0 = not used
29	Location of the user specified seasonal melt-factor variation: 8/ 0 = not used
30	Location of information needed to use rain-snow elevation time series: 9/ 0 = not used
31	Location of information on variance of observed water-equivalent time series in the PS array: 10/ 0 = none used
32	Location of information on variance of simulated water-equivalent time series in the PS array: 10/ 0 = none used

Position	Contents
33	Location of Kalman filtering updating parameters in the PS array: 11/ 0 = not used
34	Unused

Notes:

1/ Order of the rain plus melt and percent snowfall time series information:
- o identifier (2 values)
- o data type code

2/ Order of the observed and simulated water-equivalent and observed and simulated areal extent of snow cover time series information:
- o identifier (2 values)
- o data type code
- o time interval

3/ Order of the sums of water balance and melt components:
1. precipitation
2. snowfall
3. rain plus melt
4. non-rain melt
5. rain melt
6. rain on bare ground
7. residual

4/ Order of snow model parameters:
1. PXADJ
2. ELEV
3. SCF
4. MFMAX
5. MFMIN
6. UADJ
7. SI
8. NMF
9. TIPM
10. MBASE
11. PXTEMP
12. PLWHC
13. DAYGM
14. ALAT

5/ Areal depletion curve consists of decimal fraction areal extent of snow cover values at WE/A_i ratios of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8 and 0.9. Areal extent at WE/A_i=0.0 is set to 0.05 and areal extent is 1.0 when WE/A_i=1.0.

6/ Order of the temperature parameters:
1. elevation of temperature data
2. maximum temperature lapse rate
3. minimum temperature lapse rate

7/ Order of the updating parameters (all 7 values stored for Operational Forecast Program - 2 values stored for Calibration programs):

1. water-equivalent tolerance
2. areal cover tolerance

3-4. unused

5. melt factor correction
6. snowfall correction
7. wind correction

8/ User specified melt-factor variation (12 positions - decimal fraction that melt factor lies between MFMIN and MFMAX on the 16th of each month, January-December).

9/ Order of the information needed to use rain-snow elevation time series:

1.	number of pairs used to define the area-elevation curve (NPTAE)
2.	units in which the area-elevation curve was input: 0 = English units (elevations were in FT) 1 = Metric units (elevations were in M)
3-4.	identifier of the rain-snow elevation time series
5.	data type code for the rain-snow elevation time series
6 thru 5+(NPTAE·2)	area elevation curve (stored as pairs of elevation in M and decimal fraction of area below the elevation - elevations in increasing order)

10/ Order of the variance of observed and simulated water-equivalent time series information:

- o identifier (2 values)
- o data type code

11/ Order of the Kalman filtering updating parameters:

1. input error covariance matrix (2 x 2)
2. system error covariance matrix (5 x 5)
3. default monthly variance of observed water equivalent (12 values)
4. name of Rain snow elevation opertion identifier (2 values).
5. lapse rate used by this operation
6. flag indicating type of lapse rate value:
   0 = operation identifier not found so use default value
   1 = operation identifier is found so use lapse rate value from operation
   2 = perations identifier is not supplied so use default value
7. flag updating with snow cover computed by the Kalman Filter when water equivalent is updated

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

Position	Contents

1	Solid (ice) portion of water-equivalent (units of MM)
2	Heat deficit (units of MM)
3	Liquid water storage (units of MM)
4	Temperature index (units of DEGC)
5	Maximum water-equivalent since snow began to accumulate (units of MM)
6	SB (units of MM)
7	SBAESC (units of decimal fraction)
8	SBWS (units of MM)
9	Excess liquid-water in storage (units of MM)
10	Areal extent of snow cover adjustment (units of MM)
11 thru 10 + n	Lagged excess liquid-water (units of MM) $n = (5/\Delta T_p) + 2$ ΔT_p = time interval of precipitation data
11 + n	Areal extent of snow cover (units of MM)
12 + n thru 37 + n	State error covariance matrix

Subroutine Names and Functions

Subroutine	Function
AB31	Compute derivatives for non-rain melt, rain melt, water and heat
ADJC31	Adjust carryover for a change in water-equivalent
ADJP31	Adjust the state error covariance matrix for a change in water equivalent
AECO31	Adjust state variables for a change in the areal extent of snow cover
CASE31	Determine the position on the areal depletion curve
CHKX31	Check the values of the five model states and corrects any that are outside of the physical limits
CKCO31	Check carryover
COX31	Perform carryover transfer

Subroutine	Function
CSAV31	Store carryover values in the CS array
ENDO31	Set endogenous states SB, SBWS, SBAESC
EX31	Execution control subroutine
FLTR31	Compute the Kalman Gain matrix and the updated error covariance matrix and updates the model states
F031	Compute the change in model states
MELT31	Compute surface melt for rain and non-rain conditions Computes melt factor
PACK31	Execute the operation for one computation time interval
PIN31	Input cards and stores values in PS array
PRC31	Print information in CS array
PRCO31	Print carryover during debug
PROP31	Compute predicted error covariance matrix
PRP31	Print information in PS array
PRSM31	Print snow model summations
PRSN31	Print output for Operation
PUC31	Punch information in PS and CS arrays
ROUT31	Route excess water through the snow cover
STSP31	Perform the state space computations
SWST31	Switch the states to and from the SNCO31 common block
UPDT31	Update by calling the filter and allows updating outside the filter
TAB31	Make entries into the Operations Table
ZERO31	Set carryover to zero when no snow exists

Subroutines PRP31, PRC31, COX31 and PUC31 have the standard argument lists for these subroutines as given in Section VIII.4.3. PIN31 is passed two parameters in addition to the standard argument list. The first argument to the PIN31 subroutine is the entire P array. This argument is required to determine the lapse rate information from the RNSWELEV Operation. The second argument is the size of the entire P array.

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SUBROUTINE EX31 (PS,CS,PX,TA,RM,PCTS,RSTS,OWE,OWEV,SWE,SWEV,OSC,
                 COVER,PPX,PPCTS,PRM,TALR)
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Function

This is the execution subroutine for Operation SNOW-43.

Argument List

Variable	Input/ Output	Type	Dimension	Description
PS	Input	R*4	Variable	Parameter array
CS	Both	R*4	Variable	Carryover array
PX	Input	R*4	Variable	Precipitation data
TA	Input	R*4	Variable	Temperature data
RM	Output	R*4	Variable	Rain plus melt values
PCTS	Input	R*4	Variable	Percent snowfall data
RSTS	Input	R*4	Variable	Rain-snow elevation data
OWE	Input	R*4	Variable	Observed water-equivalent data
OWEV	Input	R*4	Variable	Variance of observed water-equivalent data
SWE	Output	R*4	Variable	Simulated water-equivalent values
SWEV	Output	R*4	Variable	Variance of simulated water-equivalent values
OSC	Input	R*4	Variable	Observed areal extent of snow cover data
COVER	Output	R*4	Variable	Simulated areal extent of snow cover values
PPX	-	R*4	Variable	Work space
PPCTS	-	R*4	Variable	Work space
PRM	-	R*4	Variable	Work space
TALR	-	R*4	Variable	Work space

SUBROUTINE PACK31 (KDA,KHR,NDT,TA,PX,PCTS,RSL,OWE,OWEV,GAIN,OSC,
PGM,RM,RLAPSE,TWE,TWEV,COVER,CWE,CAESC,IFUT,IDT,
IBUG,IDN,IMN)

Function: This routine executes the SNOW-43 snow model for one computational time interval.

Argument List

Variable	Input/ Output	Type	Dimension	Description
KDA	Input	I*4	1	Current Julian day - internal clock
KHR	Input	I	1	Current hour - internal clock
NDT	Input	I*4	1	Number of precipitation, percent snowfall and rain plus melt values per computational time interval
TA	Input	R*4	1	Air temperature (units of DEGC)
PX	Input	R*4	NDT	Precipitation (units of MM)
PCTS	Input	R*4	NDT	Percent snowfall (units of decimal fraction)
RSL	Input	R*4	1	Rain-snow elevation (units of M)
OWE	Input	R*4	1	Observed water-equivalent (units of MM)
OWEV	Input	R*4	1	Variance of observed water-equivalent (units of MM squared)
GAIN	Input	R*4	1	Kalman gain for observed water-equivalent
OSC	Input	R*4	1	Observed areal extent of snow cover (units of decimal fraction)
PGM	Input	R*4	1	Ground melt (units of MM)
RM	Output	R*4	NDT	Rain plus melt (units of MM)
RLAPSE	Input	R*4	1	Lapse Rate (units of DEGC/M)
TWE	Output	R*4	1	Simulated water-equivalent (units of MM)
TWEV	Output	R*4	1	Variance of simulated water-equivalent (units of MM squared)

Variable	Input/ Output	Type	Dimension	Description
COVER	Output	R*4	1	Simulated areal extent of snow cover (units of decimal fraction)
CWE	Output	R*4	1	Computed water-equivalent before any updating (units of MM)
CAESC	Output	R*4	1	Computed areal extent of snow cover before any updating (units of decimal fraction)
IFUT	Input	I*4	1	0 = observed data period 1 = forecast (future) period
IDT	Input	I*4	1	Length of computational time interval (units of HR)
IBUG	Input	I*4	1	Debug print option: 0 = do not print debug output 1 = print debug output
IDN	Input	I*4	1	Current day number since March 21
IMN	Input	I*4	1	Current month number

SUBROUTINE TAB31 (TO,LEFT,IUSET,NXT,LPS,PS,LCS,TS,MTS,NWORK,LWORK,IDT)

Function: This is the Operations Table entry subroutine for Operation SNOW-43.

Argument List: The arguments for this subroutine are similar to the arguments for the operations table entry subroutines for other operations. A description of the arguments is contained in Section VIII.4.2-TAB.

Operation Table Array: The contents of the TO array are:

Position	Contents
1	Operation number
2	Location in the T array of the next operation to be executed
3	Location of the parameter array for the operation in the P array
4	Location of the carryover array for the operation in the C array
5	Location of precipitation data in the D array
6	Location of temperature data in the D array
7	Location to put rain plus melt data in the D array: 0 = not used
8	Location of percent snowfall data in the D array: 0 = none used
9	Location of observed water-equivalent data in the D array: 0 = none used
10	Location of rain-snow elevation data in the D array: 0 = none used
11	Location to put simulated water-equivalent data in the D array: 0 = not used
12	Location of observed areal extent data in the D array: 0 = none used
13	Location to put simulated areal extent data in the D array: 0 = not used

Position	Contents
14	Location of work space in the D array