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Hydrologic Simulation Model of Colorado Subalpine Forest

by Charles F. Leaf and Glen E. Brink

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Abstract

A simulation model specifically designed to determine the probable hydrologic changes resulting from watershed management in the Colorado subalpine zone is described. The model simulates the total water balance on a continuous year-round basis and compiles the results from individual hydrologic response units into a "composite overview" of an entire drainage basin. Preliminary results are summarized for an 8-year test period on a 667-acre experimental watershed.

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**Hydrologic Simulation Model of Colorado
Subalpine Forest**

BRINK, 1973 by
Charles F. Leaf, Hydraulic Engineer
and
Glen E. Brink, Computer Programmer

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U.S. Rocky Mountain Forest and Range Experiment Station¹, 1511

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Contents

	Page
Subroutine WATBAL	2
Precipitation	2
Evapotranspiration	2
Subroutine CANVAP	4
Subroutine SNOWVAP	4
Subroutine EVTRAN	5
Available Soil Water Correction	5
Radiation Balance and Evapotranspiration	
According to Forest Cover Density	5
Seasonal Course of Transpiration	6
Subroutine RADBAL	6
Subroutine SNOWED	7
Peripheral Routines	7
Applications	8
Literature Cited	10
Appendix	12

Hydrologic Simulation Model of Colorado Subalpine Forest

Charles F. Leaf and Glen E. Brink

Leaf and Brink (1973) have previously described a model for simulating snowmelt in central Colorado subalpine watersheds. Snowmelt over an area is described in terms of combinations of aspect, slope, elevation, and forest cover composition and density.

The hydrologic model described in this report is an expanded version of the snowmelt model. The model has been programed for the CDC 6400 computer at Colorado State University. It is designed to simulate the total water balance on a continuous, year-round basis, and to compile the results from individual hydrologic subunits into a "composite overview" of an entire watershed. The model has been designed to simulate watershed management practices and their resultant effects on the

behavior of hydrologic systems. The model consists of (1) a "core" which performs the actual simulation, and (2) peripheral routines which specify hydrologic subunit parameters, obtain the input data, maintain continuity between simulation intervals, and output the results.

Figure 1 schematically shows the general flow of the model. Detailed flow chart descriptions of the water balance routines and pertinent hydrologic theory are presented in this report. Those routines which were incorporated from the snowmelt model without significant changes are not discussed here. Complete descriptions of the unrevised routines are given in Leaf and Brink (1973). The routines which were taken from the snowmelt model and

Figure 1. — General flow of hydrologic simulation model.

altered for compatibility with the water balance model are indicated by an asterisk (*) in the following tabulation.

Discussed in this report

WATBAL*
CANVAP
SNOWVAP
EVTRAN
RADBAL*
SNOWED*

Discussed in Leaf and Brink (1973)

AFFECTS
CALIN
CALOSS
DIFMOD
GETREF (now PACKREF)
LINK
MIXTURE
RAINED

Subroutine WATBAL (fig.2)

Subroutine AFFECTS from the snowmelt model (Leaf and Brink 1973) was expanded to include the decisions relating to evapotranspiration, and was renamed WATBAL. WATBAL is the primary routine in the water balance model. It receives input on a daily basis, the subunit parameters, and all state variables computed by the peripheral routines. (The only links between WATBAL and the peripheral routines are common block /WATBAL/ and the formal parameters passed at the time of the call.)

Precipitation

Precipitation (if any) is classified as discussed in AFFECTS (Leaf and Brink 1973), and the degree to which it affects the energy balance is calculated.

Evapotranspiration

Morton (1971) points out that "the relationship between potential evaporation and regional (actual) evaporation includes the effects of hydrologic and climatologic feedback." The feedback includes moisture supply and the thermal and moisture characteristics of the overlying air, which are influenced by the actual evapotranspiration. This interaction in turn has a significant influence on the energy available for evapotranspiration.

These interactions have also been taken into account by Bouchet (1963), who argued that changes in regional and potential evaporation due to changes in regional moisture supply are complementary. If the potential evapotranspiration (ET) is computed from regional climatological observations and utilized in this concept, the regional (actual) evapotranspiration, which is a product of complex climatic, soil moisture, and vegetative processes may be estimated.

Of the several empirical methods available for computing potential evapotranspiration, the one developed by

Figure 2. — Subroutine WATBAL.

Hamon (1961) appears to give the best results (Stephens and Stewart 1963, Russell and Boggess 1964, Takhar and Rudge 1970). Hamon formulated the expression:

$$E_h = CD^2P_t \quad [1]$$

for computing average potential evapotranspiration, E_h (inches/day), for each month of the year where

D = possible sunshine in units of 12 hours,
 P_t = The saturated water vapor density (absolute humidity) at the daily mean temperature in grams per cubic meter, and
 C = a coefficient (0.0055 according to Hamon).

Hamon's equation requires only latitude, converted to day length (adjusted for slope and aspect), and mean temperature, converted to saturation vapor density, for computing monthly E_h .

Equation [1] predicts the "average" evapotranspiration. In the Colorado subalpine zone, this average is less than half the amount that could occur under conditions of unlimited energy supply, assumed herein as potential solar radiation. Accordingly, the coefficient C in equation [1] was empirically adjusted upward to obtain an expression for potential evapotranspiration under maximum solar input:

$$E_m = C'D^2P_t \quad [2]$$

where C' is the adjusted coefficient. The daily potential evapotranspiration for each of 12 months as derived by equation [2] is supplied as a set of parameters for each hydrologic subunit.

To adjust maximum daily evapotranspiration for available energy, the values determined by equation [2] were modified according to the expression

$$E_s = \frac{SW}{P} E_m \quad [3]$$

where

E_s = evapotranspiration adjusted for available energy in inches/day,
 SW = the observed daily shortwave radiation in langley's,
 P = potential shortwave radiation for the day as computed by Frank and Lee (1966).

In the water balance routines, the adjusted evapotranspiration as derived above is then redefined, depending on the source, as selected by the following sequence:

1. If snow is intercepted on the forest canopy, evaporation occurs exclusively from that source and is computed by subroutine CANVAP.
2. If the canopy is free of snow, the next step in the source selection is to determine if losses result from evapotranspiration (see subroutine EVTRAN) or evaporation from the snowpack surface (see subroutine SNOWVAP). If evaporation is from the snow surface or from intercepted snow, control then passes to the radiation balance routines. If a snowpack exists, the radiation routines generate any possible melt for input; otherwise, the only input that can result is from a rain event. Subroutine EVTRAN then calculates the evapotranspiration requirements, which are taken first from the input and, if not satisfied, from the soil mantle storage.

The various methods of computing evaporation and transpiration are discussed in the descriptions of the subroutines named above.

Once the evapotranspiration requirements have been satisfied, any remaining input, either from snowmelt or rainfall, is used to satisfy the soil mantle recharge requirements (see subroutine EVTRAN). When field capacity is reached, the excess input is considered to be water available for streamflow (generated runoff).

As explained later in this report, subroutine RADBAL includes a phase indicator that determines which of two methods is to be used to compute the effects of the radiation balance. When the seasonal snowpack is completely melted, the phase indicator is reset to the "accumulation phase." It remains at that setting until certain conditions specified in subroutine RADBAL are met; it then returns to the "melt phase" setting. Upon completion of the water balance calculations, WATBAL returns the results and the new values for the state variables to the calling routine. Here, they are weighted according to the percent of the total area occupied by the various hydrologic subunits. These weighted values are then summed to generate the watershed composite.

Subroutine CANVAP (fig. 3)

Hoover and Leaf (1967), Hoover (1969), and Hoover (in press),² have discussed the process and significance of interception loss in central Colorado subalpine forests. Field studies indicate that mechanical removal of intercepted snow by wind is an important phenomenon. Accordingly, wind effects were considered in the snow interception subroutine.

In developing this portion of the model, the following assumptions were made:

1. The amount of snow intercepted varies according to forest cover type and density;
2. The intercepted snow rests on the canopy for only 1 day following the day of the snow event because turbulent winds remove the snow from the crowns; and
3. The residual intercepted snow which is not vaporized after 1 day is added to the snow-pack.

The amount of snow intercepted by spruce-fir was assumed to vary as

$$P_{if} = 0.15 \frac{C_d}{C_{dmx}} I_s \quad [4]$$

where

P_{if} = water equivalent of intercepted snow in inches

I_s = water equivalent input which occurs as snow in inches,

C_{dmx} = natural forest cover density, expressed as a decimal, and

C_d = reduced forest cover density, as a decimal.

Interception in lodgepole pine is given by the equation

$$P_{ip} = 0.10 \frac{C_d}{C_{dmx}} I_s \quad [5]$$

The assumed maximum amounts of snow interception are 0.2 and 0.3 inch for lodgepole pine and spruce-fir, respectively. Snowfall inputs which exceed the above values are added to the snowpack.

Vaporization of intercepted snow on foliage surfaces is assumed to vary as a func-

tion of forest cover density, C_d , and evapotranspiration is adjusted for available energy (equation 3) as follows:

$$V_c = \frac{1}{C_d} E_s \quad [6]$$

where

V_c = intercepted snow evaporation in inches,
 $C_d > 0$

Figure 3. — Subroutine CANVAP.

If equation [6] yields a value which is less than the water equivalent of the intercepted snow, that water equivalent is merely reduced to satisfy the evaporation requirement, V_c . However, if equation [6] indicates a greater value than the intercepted water equivalent, V_c is reduced to the point where the requirement is satisfied by the water equivalent of the snow, which is completely vaporized from the canopy.

Subroutine SNOWVAP (fig. 4)

During conditions when the canopy is free of snow, that is, when time since the beginning of the last snowfall event is greater than 2 days, it is assumed that evaporation from the snowpack beneath the trees, V_s , takes place according to the relation

$$V_s = (1 - C_d) E_s \quad [7]$$

when

$C_d = 0$ (a forest opening),

$V_s = E_s$

² Hoover, Marvin D. *Snow interception and redistribution in the forest. Third Int. Seminar for Hydrol. Professors [Purdue Univ., Lafayette, Ind., July 1971] (in press).*

Figure 4. — Subroutine SNOWVAP.

Subroutine EVTRAN (fig. 5)

Available Soil Water Correction

There has been some work with crops and forest ecosystems to indicate that transpiration decreases as available water decreases (Denmead and Shaw 1962, Cowan 1965, Swanson 1967, Swanson 1969). Accordingly, equation [3] was further adjusted to account for available soil water. Denmead and Shaw (1962) point out that, in porous soils, the decline should not be pronounced until most of the "available water" is removed. Because subalpine soils are coarse textured (Retzer, 1962), it was assumed that transpiration of

dense forest cover would proceed at rates given by equation [3] until the soil water is depleted to 50 percent of field capacity. Thereafter, transpiration is decreased in proportion to the amount of available soil water below one-half of field capacity. In open cutover areas, it was reasoned that the absence of dense vegetation would enable transpiration to proceed at rates given by equation [3] only when soil is at field capacity. In the model, it was assumed that the available soil water (mantle storage) is 5.3 inches in both the forest and open, based on an assumed average rooting depth of 4 feet, and a "wilting point" and "field capacity" of 4 percent and 15 percent by volume, respectively. Thus, equation [3] was expanded to obtain "actual" evapotranspiration in the forest, E_a , and in the open, E_{ao} , during the growing season as follows:

For Forest:

$$E_{af} = (1 - R_f) (0.377M) (E_s) \quad [8]$$

For Open:

$$E_{ao} = (1 - R_f) (0.755M - 3) (E_s) \quad [8a]$$

where

M = "available" mantle storage. When M exceeds 5.3 and 2.65 inches in the open and forest, respectively, evapotranspiration is computed by equation [3], and

R_f = reflectivity of the forest stand or open area as discussed below.

Radiation Balance and Evapotranspiration According to Forest Cover Density

Baumgartner (1967) and Tajchman (1971) have reported that evapotranspiration from coniferous forests is greater than from open land, although Tajchman reported smaller differences between forest and open land than did Baumgartner. Both Baumgartner and Tajchman discussed the differences in evapotranspiration from various cover types in terms of the differing energy balances. In presenting an analysis of the radiation balance and associated vapor loss, Baumgartner (1967) pointed out that "the only pertinent variations with regard to the latent heat flux are those associated with reflectivity..." Accordingly, a relationship

Figure 5. — Subroutine EVTRAN.

was derived between reflectivity and forest cover density (Leaf and Brink 1973) to index the reduction of evapotranspiration as forest cover is removed. For lack of any field data, the following tentative relationships were assumed:

$$R_f = 0.5 - \frac{0.75 C_d}{C_{dmx}} \quad [9]$$

where

R_f = the reflectivity of the forest stand,
 C_{dmx} = natural forest cover density, expressed as a decimal, and
 C_d = reduced forest cover density, as a decimal.

Equation [9] only applies when $C_d \leq \frac{C_{dmx}}{3}$.

When $C_d > \frac{C_{dmx}}{3}$, the reflectivity is given by

$$R_f = 0.25 - \frac{0.15}{0.67 C_{dmx}} (C_d - 0.33 C_{dmx}) \quad [10]$$

The relationship given by equations [9] and [10] is plotted in figure 6. Note that when cover density $C_d = C_{dmx}$, $R_f = 0.1$, whereas when $C_d = 0$, $R_f = 0.5$. These values qualitatively agree with values given by Baumgartner (1967), who summarized variations of absorption coefficient for several cover types, and Burroughs (1971), who developed a shortwave reflectivity model for lodgepole pine forest which accounts for varying stand characteristics and season of the year.

Figure 6. — Assumed variation of reflectivity (R_f) as a function of forest canopy density (C_d).

Seasonal Course of Transpiration

Swanson (1967) observed that transpiration can occur early in the snowmelt runoff season when there is still considerable snow cover. At the Fraser Experimental Forest, during the first week in May 1965, he observed a sharp upturn in sap flow when the snow cover still held an average of more than 5 inches of residual water equivalent. Accordingly, a threshold water equivalent was assumed in the model after which evapotranspiration is allowed to occur. This threshold is tentatively estimated to be 5 inches. Evapotranspiration is computed by equations [8] or [8a] above, and varies according to available energy, E_s , available mantle storage, M , and reflectivity, R_f , all of which have been discussed previously.

Once the evapotranspiration requirements have been established by the above adjustments, they are satisfied first from the input and then from the soil mantle storage. If the requirements would deplete storage below the wilting point, however, all values are adjusted to cause evapotranspiration to cease at that point.

During the winter, evapotranspiration is computed by equations [8] or [8a], provided the forest canopy is free of snow and the snowpack water equivalent is less than the critical 5 inches. When the snowpack exceeds 5 inches, only evaporation from intercepted snow and from the snow surface takes place.

Subroutine RADBAL (fig. 7)

This routine is essentially identical to the routine by the same name in the snowmelt model (Leaf and Brink 1973). The only changes necessary were to modify the calculations for year-round processing. Hence, the modification in RADBAL consists of a phase switch, which indicates optional methods of computing the radiation balance.

During the fall and winter before the diffusion model achieves mathematical stability (Leaf and Brink 1973), only shortwave radiation is used to compute snowmelt. Therefore, the only cold content in the snowpack results from newly fallen snow. (To insure snowpack accumulation during this phase, snowmelt is not "allowed" to take place on days when the mean air temperature is below 0° C.). Once the snowpack depth is sufficient for diffusion model stability (4.7 inches of water equivalent), the phase switch is reset to compute snowmelt according to the snowmelt simulation model (Leaf and Brink

1973). In other words, when the snowpack reaches the specified depth in the early winter, the switch is set to "melt when ready." The snowpack will continue to accumulate in this phase until the normal all-wave radiation balance produces snowmelt. The switch is reset to the snow accumulation phase at the end of the snowmelt season (when snowpack water equivalent is zero).

Figure 7. — Subroutine RADBAL.

Subroutine SNOWED (fig. 8)

The only difference between this routine and its counterpart in the snowmelt model (Leaf and Brink 1973) is the inclusion of interception calculations. The amount of snow intercepted on a given day is computed as a percentage, which is determined by the

Figure 8. — Subroutine SNOWED.

vegetation type as discussed in subroutine CANVAP. The total amount which may remain on the canopy after several consecutive snow events is also determined by vegetation type.

Peripheral Routines

The peripheral routines are not flow-charted or discussed in detail on an individual basis, since they are primarily utility routines for input, output, and maintenance of continuity between simulation intervals. Subroutines GENDATA, RADCOMP, and RDMSTR are all concerned with input, and use various analyses to generate the daily input for each substation from observed base station data. Subroutines ETCODE and PLOTTER are output routines which aid in the interpretation of results.

All of the above routines are utilized on each run of the model, but to save time and core, most output options are included as overlays, only one of which is selected at a

time to occupy core and process the data. Each overlay consists of a control routine, a normal simulation routine, a write routine, and any watershed management alternative simulation routines that may be needed.

A complete listing of the model described in this report is included in the appendix.

Applications

We have used the hydrologic model to simulate area snowmelt and water yield from the 667-acre Deadhorse Creek watershed at the Fraser Experimental Forest (Leaf 1971; Leaf and Brink 1972, 1973). Physical characteristics of this watershed vary from low-elevation (9,300 ft. m.s.l.) south slopes in lodgepole pine forest to high-elevation (11,000 ft.) north slopes in spruce-fir. Simulations from 10 subunits on the basin were weighted according to the percentage of the total area each represents to generate the watershed composite. Each subunit was selected according to forest cover type and density, slope,

aspect, and average elevation. Simulations of the 1963-70 water years (October 1 to September 30) indicate to us that the model represents the inherent hydrologic characteristics of Colorado subalpine watersheds. Sample output in the form of 10-day summations for the 1967 water year is shown in table 1. Figure 9 summarizes 10-day fluctuations of several hydrologic variables for the 1965 water year. Figure 10 compares simulated and observed annual water yields from Deadhorse Creek for the 1964-71 record period.

We have predicted the change in rate and seasonal time distribution of snowmelt resulting from clearcutting small openings in old-growth forest with the snowmelt portion of the model (Leaf and Brink 1972). With the increased water balance simulation capability, we plan to develop the model into a useful tool for predicting the hydrologic consequences of several resource management practices. In the Colorado subalpine zone, these include weather modification and timber harvesting.

Figure 9. — Simulated 10-day fluctuations of several hydrologic components during the 1965 water year on Deadhorse Creek, Fraser Experimental Forest.

Table 1.--Water balance simulation, 1967 water year
Fraser Experimental Forest, Deadhorse Creek - 667 acres

Date	Current			Interval totals				Year to date			
	Snowpack water equivalent	Recharge require- ment	Precipitation	Input	Evapo- transpiration from--1	Generated runoff	Precipitation	Input	Evapo- transpiration	Generated runoff	Change in recharge requirement
10 10 66	0.16	-2.84	0.86	0.62	0.3498 C E	0.05	0.86	0.62	0.3498	0.05	0.29
10 20 66	.46	-2.60	.85	.47	.2687	.04	1.70	1.09	.6186	.09	.54
10 30 66	.34	-2.80	.00	.12	.3168 E	.00	1.70	1.21	.9354	.09	.34
11 10 66	1.43	-2.80	1.25	.08	.1571 C E	.00	2.95	1.30	1.0925	.09	.34
11 20 66	1.45	-2.85	.06	.04	.0959 C E	.00	3.01	1.33	1.1884	.09	.28
11 30 66	1.75	-2.87	.39	.05	.0971 C E	.00	3.40	1.38	1.2855	.09	.27
12 10 66	3.69	-2.87	2.04	.01	.1017 CSE	.00	5.44	1.39	1.3872	.09	.26
12 20 66	3.73	-2.90	.05	.00	.0333 CSE	.00	5.48	1.39	1.4205	.09	.23
12 30 66	3.87	-2.93	.15	.00	.0404 CSE	.00	5.63	1.39	1.4610	.09	.21
1 10 67	4.92	-2.93	1.14	.00	.1000 CSE	.00	6.77	1.39	1.5610	.09	.20
1 20 67	6.43	-2.94	1.64	.00	.1223 CSE	.00	8.41	1.39	1.6833	.09	.20
1 30 67	7.16	-2.92	.83	.02	.0907 CSE	.00	9.24	1.41	1.7740	.09	.21
2 10 67	8.49	-2.93	1.46	.00	.1179 CSE	.00	10.70	1.41	1.8920	.09	.21
2 20 67	10.69	-2.93	2.36	.00	.1788 CS	.00	13.06	1.41	2.0708	.09	.21
3 10 67	11.90	-2.93	1.49	.00	.2775 CS	.00	14.55	1.41	2.3483	.09	.21
3 20 67	13.20	-2.88	1.61	.05	.2612 CS	.00	16.16	1.46	2.6095	.09	.25
3 30 67	13.31	-2.68	.48	.20	.1762 CS	.00	16.64	1.66	2.7857	.09	.45
4 10 67	12.92	-2.43	.35	.42	.3183 CS	.16	16.99	2.08	3.1039	.26	.71
4 20 67	12.69	-1.87	.93	.87	.3418 CSE	.26	17.92	2.95	3.4457	.52	1.26
4 30 67	12.35	-1.45	.78	.89	.2632 CSE	.43	18.70	3.85	3.7089	.95	1.68
5 10 67	11.63	-1.35	.57	.94	.4397 CSE	.75	19.27	4.78	4.1487	1.70	1.78
5 20 67	9.49	-.58	.57	2.42	.3761 CSE	1.55	19.83	7.20	4.5247	3.26	2.56
5 30 67	6.04	-.07	.38	3.51	.5529 CSE	2.78	20.21	10.71	5.0777	6.03	3.06
6 10 67	2.83	-.27	.47	3.36	.9556 CSE	2.92	20.68	14.07	6.0333	8.96	2.86
6 20 67	1.47	-.05	1.58	2.85	.4260 CSE	2.29	22.26	16.92	6.4593	11.25	3.09
6 30 67	.68	-.54	.82	1.56	1.1143 CSE	.98	23.08	18.48	7.5736	12.23	2.59
7 10 67	.00	-1.34	.58	1.24	1.3991 SE	.66	23.66	19.71	8.9727	12.88	1.80
7 20 67	.00	-2.46	.40	.40	1.5228 E	.00	24.06	20.11	10.4955	12.88	.68
7 30 67	.00	-3.12	.58	.58	1.2406 E	.00	24.63	20.69	11.7362	12.88	.01
8 10 67	.00	-2.83	1.13	1.13	.8239 E	.02	25.76	21.82	12.5601	12.90	.30
8 20 67	.00	-3.58	.12	.12	.8617 E	.00	25.88	21.94	13.4218	12.90	-.44
8 30 67	.00	-3.95	.17	.17	.5433 E	.00	26.05	22.11	13.9651	12.90	-.81
9 10 67	.00	-4.17	.11	.11	.3346 E	.00	26.16	22.22	14.2997	12.90	-1.04
9 20 67	.00	-3.04	1.53	1.46	.3502 C E	.04	27.69	23.68	14.6499	12.94	.10
9 30 67	.00	-3.17	.47	.46	.5844 C E	.02	28.16	24.14	15.2343	12.96	.04

1 C = interception loss
S = Evaporation from snowpack
E = Evapotranspiration

Figure 10. — Simulated versus observed annual runoff on Deadhorse Creek, 1964-71.

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Appendix I: Routines for Water Balance Model

Program WBMODEL

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OVERLAY (OLAYS,D,0)
PRDGRAM WBMODEL (INPUT,OUTPUT,PLOTS,TAPE5=INPUT,TAPE6=OUTPUT,
1 TAPE11=PLOTS)
C----- THIS IS THE CONTROLLING ROUTINE FOR THE WATER BALANCE MODEL. THE
C----- MODEL IS OVERLAYED TO SAVE TIME AND MEMORY. THE CORE OF THE MODEL
C----- IS SUBROUTINE WATBAL AND ITS RELATED ROUTINES. ALL OF THESE, PLUS
C----- SEVERAL I/O ROUTINES WHICH HAVE NO OPTIONS, ARE INCLUDED IN THIS
C----- MAIN OVERLAY SO THEY ARE AVAILABLE TO THE OVERLAYS WHICH ARE
C----- SELECTED BY OPTION. THE FIRST OVERLAY LOADED ESTABLISHES THE
C----- WATERSHED DESCRIPTORS AND PARAMETERS AND INDICATES THE OVERLAYS
C----- TO BE SELECTED ACCORDING TO THE OUTPUT OPTIONS. THE NEXT OVERLAY
C----- TO BE LOADED WILL CONTAIN THE OUTPUT ROUTINE SELECTED AND ITS
C----- NORMAL SIMULATION ROUTINE. IT WILL THEN LOAD ONE OF ITS
C----- SECONDARY OVERLAYS WHICH WILL CONTAIN THE MAIN OPERATING PROGRAM
C----- FOR THIS RUN AND ANY ALTERNATIVES THAT ARE TO BE INCLUDED.
C-----
C----- THE CORE OF THE MODEL (SUBROUTINE WATBAL, ET AL) IS DESIGNED TO
C----- FUNCTION AS AN INDEPENDENT UNIT, TOTALLY UNCONCERNED WITH I/O AND
C----- MAINTENANCE OF CONTINUOUS OR STATIC CONDITIONS. THE ONLY LINKS
C----- WITH THE OPERATING PROGRAM, ITS ALTERNATIVES AND I/O ROUTINES,
C----- ARE THE FORMAL PARAMETERS AND COMMON BLOCK /WATBAL/. EACH
C----- ROUTINE WHICH UTILIZES THE CORE MUST MAINTAIN ITS OWN SET OF
C----- CONTINUOUS CONDITIONS AND MAKE THEM AVAILABLE AT THE PROPER TIME
C----- FOR USE BY THE CORE. THE BLANK COMMON AND LABELLED COMMON BLOCKS
C----- ESTABLISHED HERE IN THE MAIN OVERLAY ARE PRIMARILY FOR THE USE OF
C----- THE NORMAL SIMULATION ROUTINE. THEREFORE, SIMILAR LOCATIONS MUST
C----- BE SET ASIDE FOR MAINTENANCE BY ANY AND ALL ALTERNATIVES.
COMMON AIRTEMC(25,6)
COMMON CALDEF(25),COMMAX(25),COVDEN(25)
COMMON DREADY(25)
COMMON ENGBAL(25),ET,ETDA(LY(25),12)
COMMON FREEWAT(25)
COMMON ISOTHRM(25,20)
COMMON LASTUSD(25),LEVEL1,LEVEL2
COMMON MMD
COMMON NDAYSND(25),NDIVSBL,NSUB,NYEARS
COMMON ONTREES(25)
COMMON PEAKPPT(25,20),PEAKWE(25,20),PHASE(25),PDENT(24),
1 PREWEQV(25)
COMMON RECHRG(25)
COMMON SIMTEM1(25,3),SUBID(25,6),SLPASP(25,24)
COMMON TCDEFF(25),THRSHTD(25),TOPLDT(11)
COMMON VEGTYPE(25)
COMMON WEIGHT(25),WSHEDID(16)
COMMON YEARS(20),YMMOD
INTEGER DREADY
INTEGER PHASE
INTEGER SUBID
INTEGER TOPLOT
INTEGER VEGTYPE
INTEGER WSHEDID
INTEGER YEARS,YMMOD
COMMON/CMPSTO/COMPS(16),YRTOT(5)
COMMON/MASTER/DATE(3),TMXSTR,TMNMSTR,PPTMSTR,PPTNDW,DBSHYDR,
1 POTRAQ,MSTREOF,IYR
INTEGER DATE
COMMON/WATBAL/ETFROM,EVAPDTR,GENRO,PRECIP,RADIN,RADLWN,RADSWN,
1 TEMPMAX,TEMPMIN,WATERIN
DATA COMPS,YRTOT/21*0,D/
DATA IYR,MSTREOF/1,0/
CALL OVERLAY (SHOLAYS,1,0)
CALL OVERLAY (SHOLAYS,LEVEL1,D)
C----- FILE -PLOTS- IS COPIED TO -OUTPUT- BY A STANDARD MONITOR COPY
END

```

Subroutine WATBAL

```

SUBROUTINE WATBAL (F1,F2,F3,I1,F4,F5,I2,I3,F6,I4,F7,F8,F9,F10,F11,
1 F12,F13,I5)
C----- THIS SUBROUTINE IS THE MAIN ROUTINE OF THE WATER BALANCE MODEL. IT
C----- RECEIVES THE DRIVING, STATIC AND CONTINUOUS VARIABLES FROM THE
C----- OPERATING ROUTINES, CONTROLS THE COMPUTATIONS ON THEM, AND
C----- RETURNS THE NEW VALUES FOR THE CONTINUOUS VARIABLES AND THE
C----- RESULTS OF THIS INTERVAL. SEE THE REPLACEMENT STATEMENTS BELOW
C----- FOR THE VARIABLE DEFINITIONS OF THE PARAMETERS
C
C----- DICTIONARY OF WATER BALANCE COMMON BLOCKS
C
C
C AVETEMC - THE MEAN TEMPERATURE FOR THE INTERVAL IN DEGREES C
C BASTEMF - BASE TEMPERATURE DEGREES FARENHEIT, RAIN TURNS TO SNOW
C CALDEF - THE CALORIC DEFICIT IS THE NUMBER OF CALORIES NEEDED
C TO BRING THE SNOWPACK TEMPERATURE TO ZERO DEGREES
C CENTIGRADE (NOTE SHOULD BE MADE THAT IT IS A POSITIVE
C QUANTITY)
C COVDEN - THE COVER DENSITY IS THE FRACTION OF THE GROUND OR SNOW
C SURFACE SHADED FROM DIRECT SUNLIGHT OR RADIATION
C DREADY = 0, DIFFUSION MODEL (SUBROUTINE DIFMOD) NOT INITIALIZED
C = 1, DIFFUSION MODEL INITIALIZED AND READY FOR SNOWPACK
C TEMPERATURE SIMULATION
C = -1, DIFFUSION MODEL MAY NOT BE USED
C ENGBAL - THE TOTAL CALORIC INPUT TO OR LOSS FROM THE SNOWPACK
C DURING AN INTERVAL. IT IS THE ALGEBRAIC SUM OF THE
C ENERGY INVOLVED WITH THE PRECIPITATION AND THAT OF
C THE RADIATION BALANCE
C ENGBAL1 - THE VALUE OF -ENGBAL- AT THE END OF THE LAST INTERVAL
C ETFROM = 1, EVAPORATION IS FROM THE CANOPY
C = 2, EVAPORATION IS FROM THE SURFACE OF THE SNOWPACK
C = 4, EVAPOTRANSPIRATION IS FROM SNOWMELT, RAIN OR THE
C SOIL MANTLE STORAGE

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C
C EVAPDTR - WHEN FIRST RECEIVED, THIS VARIABLE IS THE POTENTIAL
C EVAPOTRANSPIRATION AS COMPUTED BY THE HAMON METHOD
C AND ADJUSTED FOR AVAILABLE RADIATION. AFTER ACTION
C IS TAKEN BY THE WATER BALANCE ROUTINES, THE ORIGINAL
C VALUE HAS BEEN ADJUSTED FURTHER BY THE METHODS
C DISCUSSED IN SUBROUTINES CANVAP, EVTRAN, AND SNOWVAP.
C IT THEN REPRESENTS THE EVAPOTRANSPIRATION DURING THIS
C INTERVAL
C
C FREEWAT - THE FREE WATER BEING HELD BY THE SNOWPACK
C LASTUSD - AN INDICATOR USED IN FUNCTION PACKREF TO DETERMINE
C WHICH REFLECTIVITY FUNCTION TO USE
C NDAYSND - THE NUMBER OF DAYS SINCE NEW SNOW HAS FALLEN
C ONTREES - THE VOLUME OF INTERCEPTED SNOW REMAINING ON THE CANOPY
C PHASE = -1, THE SNOWPACK HAS BARELY ACCUMULATED TO THE POINT WHERE
C THE DIFFUSION MODEL IS STABLE AND MAY BE USED TO
C CONTROL THE SNOWPACK TEMPERATURE
C = 0, THE SNOWPACK IS ACCUMULATING AND HAS NOT YET REACHED
C A DEPTH WHICH WILL PROVIDE STABILITY FOR THE
C DIFFUSION MODEL
C = 1, THE SNOWPACK HAS REACHED A SUFFICIENT DEPTH TO ALLOW
C THE DIFFUSION MODEL TO CONTROL THE PACK TEMPERATURE
C UNTIL THE MELT SEASON, WHEN THE RADIATION ROUTINES
C RESUME CONTROL TO GOVERN THE MELT PHASE
C
C PRECIP - OBSERVED PRECIPITATION IN INCHES
C PREWEQV - PREDICTED WATER EQUIVALENT OF THE SNOWPACK IN INCHES
C RADIN - RADIATION IN IS THE TOTAL INCIDENT SHORT WAVE RADIATION
C RADLWN - NET LONG WAVE RADIATION IS THE ALGEBRAIC SUM OF THE LONG
C WAVE RADIATION FROM THE FOREST AND THE LONG WAVE
C RADIATION LOST BY THE SNOWPACK TO THE CANOPY
C RADSWN - THE CALORIC INPUT TO THE PACK BY THE NET SHORT WAVE
C RADIATION
C RECHRG - THE RECHARGE REQUIREMENTS, OR SOIL MANTLE STORAGE DEFICIT
C SIMTEM1 - AN ARRAY USED PRIMARILY IN SUBROUTINE DIFMOD IN THE
C SIMULATION OF THE AVERAGE SNOWPACK TEMPERATURE.
C TO INSURE STABILITY OF THE DIFFUSION MODEL, THE
C DAY IS PARTITIONED INTO 12 HOUR INTERVALS, AS
C DISCUSSED IN SUBROUTINE DIFMOD. THIS ARRAY STORES
C THE CONDITIONS PRESENT DURING THIS INTERVAL FOR USE
C IN THE SIMULATION ON THE NEXT INTERVAL. LOCATION 1
C STORES THE AVERAGE AIR TEMPERATURE (ASSUMED TO BE
C THE SURFACE TEMPERATURE OF THE SNOWPACK), LOCATION 2
C IS THE SNOWPACK TEMPERATURE AT A NODE MIDWAY
C BETWEEN THE SURFACE AND THE GROUND, AND LOCATION 3 IS
C THE GROUND TEMPERATURE.
C TCDEFF - THE TRANSMISSIVITY COEFFICIENT USED TO ESTIMATE THE NET
C SHORT WAVE RADIATION REACHING THE SNOWPACK. SEE
C REIFSNYDER AND LULL, RADIANT ENERGY IN RELATION TO
C FORESTS, USFS TECH. BUL 1344, 1965.
C TEMPMAX - THE MAXIMUM TEMPERATURE DURING THE INTERVAL IN DEGREES
C FARENHEIT
C TEMPMIN - THE MINIMUM TEMPERATURE DURING THE INTERVAL IN DEGREES
C FARENHEIT
C THRSHTD - THE THRESHOLD TEMPERATURE FOR DETERMINING WHETHER OR NOT
C TO RE-INITIALIZE THE REFLECTIVITY FUNCTION WHEN
C THERE IS A SNOW EVENT. IF THE MAXIMUM TEMPERATURE IS
C GREATER THAN THE THRESHOLD VALUE DO NOT RE-INITIALIZE
C THE FUNCTION REGARDLESS OF THE PRECIPITATION
C
C WATERIN - THE SUM OF ANY SNOWMELT AND ANY RAIN WHICH PROVIDES
C DIRECT INPUT TO THE WATER BALANCE
C
COMMON/ONLYCOR/ AVETEMC,BASTEMF,CALDEF,COMMAX,COVDEN,DREADY,ENGBAL,
1 ENGBAL1,FREEWAT,LASTUSD,NDAYSND,ONTREES,PHASE,PREWEQV,RECHRG,
2 SIMTEM1(3),SIMTEM3,TCDEFF,THRSHTD,VEGTYPE
COMMON/WATBAL/ETFROM,EVAPDTR,GENRO,PRECIP,RADIN,RADLWN,RADSWN,
1 TEMPMAX,TEMPMIN,WATERIN
DATA AVETEMC,BASTEMF,CALDEF,COMMAX,COVDEN,DREADY,ENGBAL,ENGBAL1,
1 FREEWAT,LASTUSD,NDAYSND,ONTREES,PHASE,PREWEQV,RECHRG,SIMTEM1,
2 SIMTEM3,TCDEFF,THRSHTD,VEGTYPE/0.0,35.0,3*0.0,0.2*-1.0,D,D,2*0,
3 0.0,D,6*0.0,1.0,0.0,1/
C----- OBTAIN THE STATION DESCRIPTORS
COVDEN = F3
COMMAX = F2
TCDEFF = F12
VEGTYPE = I5
C----- RECALL THE CONTINUOUS VARIABLES NECESSARY FOR THE OPERATION OF THE
C----- MODEL DURING THIS INTERVAL
CALDEF = F1
DREADY = I1
ENGBAL1 = F4
FREEWAT = F5
LASTUSD = I2
NDAYSND = I3 + I
ONTREES = F6
PHASE = I4
PREWEQV = F7
RECHRG = F8
THRSHTD = F13
IF(DREADY) 20,2D,1D
10 SIMTEM1(1) = F9
SIMTEM1(2) = F10
SIMTEM1(3) = F11
C----- AVETEMC = ((ITEMPMAX-32)*(TEMPMIN-32))/2)*(5/9)
20 AVETEMC = (ITEMPMAX + TEMPMIN - 64.0) * 0.2777777778
C----- START THE ENERGY BALANCE AND THE INPUT AT ZERO FOR THIS INTERVAL
ENGBAL = 0.0
WATERIN = 0.0
C----- IF THERE IS NO PRECIP, THERE IS NO NEED TO PASS THROUGH THE
C----- CLASSIFICATION STATEMENTS
IF(PRECIP) 90,90,3D
C----- SEE IF THE PRECIP IS ALL SNOW

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30 IF(TEMPMIN.LE.32.0.OR.STEMPMF.LT.BASTEMF) GO TO B0
C-----SEE IF ANY OF IT IS SNOW
IF(TEMPMIN - BASTEMF) 40,50,50
40 CALL MIXTURE
GO TO 90
C-----THIS IS A RAIN EVENT. IF THERE IS NO PACK, THE RAIN IS DIRECT
C-----INPUT TO THE WATER BALANCE. BUT IF THERE IS A PACK, DETERMINE
C-----THE EFFECTS OF THE RAIN
50 (F(PREWEQV) 60,60,70
60 WATERIN = PRECIP
GO TO 160
70 CALL RAINEO (AVETEMF,PRECIP)
GO TO 90
C-----THIS IS A SNOW EVENT
80 CALL SNOWEO (AMIN1 (AVETEMF,0.0),PRECIP)
C-----IF THERE IS SNOW ON THE TREES, EVAPORATE ONLY FROM THE CANOPY
90 IF(ONTREES) 130,130,100
100 CALL CANVAP
C-----ON THE FIRST DAY AFTER FRESH SNOW, ASSUME TURBULENCE HAS REMOVED
C-----ANY REMAINING INTERCEPTED SNOW AND ADD IT TO THE PACK
IF(NOAYSNO - 1) 120,110,110
110 PREWEQV = PREWEQV + ONTREES
ONTREES = 0.0
C-----IF THERE IS NO SNOWPACK, BYPASS THE RADIATION ROUTINES
120 IF(PREWEQV) 190,190,180
C-----DETERMINE WHETHER TO SATISFY THE EVAPOTRANSPIRATION REQUIREMENTS
C-----UNDER GROWING SEASON OR WINTER CONDITIONS
130 IF(PREWEQV) 160,160,140
140 IF(PREWEQV - 5.0) 150,150,170
C-----USE THE GROWING SEASON ROUTINES TO INCLUDE TRANSPIRATION
150 CALL RAOBAL
C-----ADD -WATERIN- TO THE RECHARGE REQUIREMENTS SO THE ET ROUTINE CAN
C-----OPERATE ON THE INPUT AS WELL AS THE STORAGE
160 RECHRG = RECHRG + WATERIN
CALL EVTRAN
GO TO 200
C-----USE THE WINTER ROUTINES TO EVAPORATE FROM THE SNOWPACK SURFACE
170 CALL SNOWWAP
180 CALL RAOBAL
C-----ADD -WATERIN- TO THE RECHARGE REQUIREMENTS
190 RECHRG = RECHRG + WATERIN
C-----IF THE RECHARGE REQUIREMENTS WERE SATISFIED, THE EXCESS IS
C-----CONSIDERED TO BE GENERATED RUNOFF
200 IF(RECHRG) 220,220,210
210 GENRO = RECHRG
F8 = 0.0
GO TO 230
220 GENRO = 0.0
F8 = RECHRG
230 I1 = OREAQY
F1 = CALOEF
F4 = ENGBAL
F5 = FREEWAT
I2 = LASTUSO
I3 = NOAYSNO
F6 = ONTREES
F7 = PREWEQV
C-----WHEN THE PACK IS GONE, RESET THE PHASE INDICATOR
IF(PREWEQV) 240,240,250
240 I4 = 0
RETURN
250 I4 = PHASE
IF(OREAQY) 270,270,260
260 F9 = SIMTEM1(1)
F10 = SIMTEM1(2)
F11 = SIMTEM1(3)
270 RETURN
END

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Subroutine CALIN

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SUBROUTINE CALIN (CALORIN)
C-----THIS SUBROUTINE COMPUTES THE EFFECTS OF THE CALORIC INPUT ON THE
C-----SNOWPACK
C-----HOLOCAP = THE FREE WATER HOLDING CAPACITY OF THE SNOWPACK
C-----ASSUMED TO BE FOUR PERCENT OF THE WATER EQUIVALENT)
C-----
COMMON/ONLYCOR/ AVETEMF,BASTEMF,CALOEF,COMAX,COVOEN,OREAQY,ENGBAL
I ENGBAL1,FREEWAT,LASTUSO,NOAYSNO,ONTREES,PHASE,PREWEQV,RECHRG,
2 SIMTEM1(3),SIMTEM3,TCOEFF,THRSLO,VEGTYP
INTEGER OREAQY,PHASE,VEGTYP
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RAOIN,RAOLWN,RAOSWN,
1 TEMPMAX,TEMPMIN,WATERIN
C-----ADD THESE CALORIES INTO THE ENERGY BALANCE
ENGBAL = ENGBAL + CALORIN
C-----SEE IF A CALORIE DEFICIT EXISTS IN THE PACK
COMPARE = CALORIN - CALOEF
IF(COMPARE) 10,20,30
C-----THERE IS A CALORIE DEFICIT, BUT THE INPUT DID NOT COMPLETELY
C-----WIPE IT OUT. ALL OTHER CONDITIONS ARE UNCHANGED
10 CALOEF = - COMPARE
RETURN
C-----THE CALORIE DEFICIT WAS WIPEO OUT, BUT ALL OTHER CONDITIONS ARE
C-----UNCHANGED
20 CALOEF = 0.0
RETURN
C-----ANY DEFICIT WHICH DID EXIST WAS WIPEO OUT. COMPUTE THE POTENTIAL
C-----MELT FROM THE REMAINING CALORIES (CALORIES/(80.0 * 2.54))
30 POTMELT = COMPARE/203.2
CALOEF = 0.0
C-----IF THE INPUT WAS ENOUGH TO MELT THE WHOLE PACK, CONTRIBUTE THE
C-----WATER EQUIVALENT TO THE SNOWMELT AND ZERO ALL CONDITIONS
IF(POTMELT.LT.PREWEQV-FREEWAT) GO TO 40
WATERIN = WATERIN + PREWEQV
PREWEQV = 0.0

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FREEWAT = 0.0
RETURN
C-----DELETE THE ICE PACK BY THE AMOUNT MELTED AND CONTRIBUTE THAT
C-----AMOUNT TO THE FREE WATER
40 FREEWAT = FREEWAT + POTMELT
C-----COMPUTE THE NEW HOLDING CAPACITY OF THE PACK AND COMPARE IT WITH
C-----THE FREE WATER TO SEE IF SNOWMELT IS PRODUCED
HOLOCAP = 0.04 * (PREWEQV - FREEWAT)
COMPARE = FREEWAT - HOLOCAP
IF(COMPARE.LE.0.0) RETURN
C-----THE SNOWMELT CONTRIBUTED IS IN -COMPARE-. REDUCE THE FREE WATER
C-----TO LEAVE A PRIMEO PACK AND REDUCE THE PREDICTED WATER EQUIVALENT
PREWEQV = PREWEQV - COMPARE
WATERIN = WATERIN + COMPARE
FREEWAT = HOLOCAP
RETURN
END

```

Subroutine CALOSS

```

SUBROUTINE CALOSS (CALOUT)
C-----THIS SUBROUTINE COMPUTES THE EFFECTS OF THE CALORIC LOSS ON THE
C-----SNOWPACK
COMMON/ONLYCOR/ AVETEMF,BASTEMF,CALOEF,COMAX,COVOEN,OREAQY,ENGBAL,
1 ENGBAL1,FREEWAT,LASTUSO,NOAYSNO,ONTREES,PHASE,PREWEQV,RECHRG,
2 SIMTEM1(3),SIMTEM3,TCOEFF,THRSLO,VEGTYP
INTEGER OREAQY,PHASE,VEGTYP
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RAOIN,RAOLWN,RAOSWN,
1 TEMPMAX,TEMPMIN,WATERIN
C-----ADD ALGEBRAICALLY THESE CALORIES INTO THE ENERGY BALANCE
ENGBAL = ENGBAL + CALOUT
C-----SEE IF THERE IS ANY FREE WATER IN THE PACK. IF NOT, THE LOSS IS
C-----JUST CONTRIBUTED TO THE CALORIC DEFICIT OF THE SNOWPACK.
C-----REMEMBER THAT -CALOUT- IS NEGATIVE
IF(FREEWAT.GT.0.0) GO TO 10
CALOEF = CALOEF - CALOUT
RETURN
C-----COMPUTE THE CALORIC LOSS NECESSARY TO FREEZE ALL OF THE FREE WATER
C----- (FREE WATER * 80.0 * 2.54)
10 CALNEEO = FREEWAT * 203.2
C-----NOW COMPARE THAT NECESSARY LOSS WITH THE ACTUAL LOSS. IF THEY ARE
C-----THE SAME, THE FREE WATER IS WIPEO OUT BUT NO OTHER CONDITIONS ARE
C-----ALTERED
COMPARE = CALOUT + CALNEEO
IF(COMPARE) 20,30,40
C-----THE LOSS WAS MORE THAN ENOUGH TO FREEZE IT. THE BALANCE CREATES
C-----AN ENERGY DEFICIT IN THE PACK AND THE FREE WATER IS WIPEO OUT
20 CALOEF = - COMPARE
30 FREEWAT = 0.0
RETURN
C-----ONLY PART OF THE FREE WATER FROZE. COMPUTE THE BALANCE REMAINING
C-----BALANCE = EXISTING FREE WATER - AMOUNT FROZEN, WHERE
C-----AMOUNT FROZEN = CALORIES/(80.0 * 2.54)
40 FREEWAT = FREEWAT + (CALOUT/203.2)
RETURN
END

```

Subroutine CANVAP

```

SUBROUTINE CANVAP
C-----COMPUTE THE EVAPORATION FROM THE INTERCEPTED SNOW AS A FUNCTION OF
C-----THE CANOPY COVER DENSITY
COMMON/ONLYCOR/ AVETEMF,BASTEMF,CALOEF,COMAX,COVOEN,OREAQY,ENGBAL,
1 ENGBAL1,FREEWAT,LASTUSO,NOAYSNO,ONTREES,PHASE,PREWEQV,RECHRG,
2 SIMTEM1(3),SIMTEM3,TCOEFF,THRSLO,VEGTYP
INTEGER OREAQY,PHASE,VEGTYP
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RAOIN,RAOLWN,RAOSWN,
1 TEMPMAX,TEMPMIN,WATERIN
ETFROM = 1.0
EVAPOTR = EVAPOTR/COVOEN
ONTREES = ONTREES - EVAPOTR
IF(ONTREES) 10,20,20
10 EVAPOTR = ONTREES + EVAPOTR
ONTREES = 0.0
20 RETURN
END

```

Subroutine DIFMOD

```

SUBROUTINE DIFMOD
C-----THIS SUBROUTINE WAS DERIVED FROM PROGRAM SIMTEM, A SNOWPACK
C-----TEMPERATURE DIFFUSION MODEL DEVELOPED BY LEAF (1970 STUDY PLAN
C-----FS-RM-1602, NO. 224, RMF-RES). USING THE AVERAGE SURFACE TEMP
C-----AND THE GROUND TEMP AS BOUNDARY CONDITIONS, THE NEW AVERAGE
C-----SNOWPACK TEMPERATURE IS CALCULATED
COMMON/ONLYCOR/ AVETEMF,BASTEMF,CALOEF,COMAX,COVOEN,OREAQY,ENGBAL,
1 ENGBAL1,FREEWAT,LASTUSO,NOAYSNO,ONTREES,PHASE,PREWEQV,RECHRG,
2 SIMTEM1(3),SIMTEM3,TCOEFF,THRSLO,VEGTYP
INTEGER OREAQY,PHASE,VEGTYP
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RAOIN,RAOLWN,RAOSWN,
1 TEMPMAX,TEMPMIN,WATERIN
C-----
C-----DICTIONARY
C
C CONST1 - THE FIRST CONSTANT IN THE EQUATION FOR THE SIMULATION
C CONST2 - THE SECOND CONSTANT IN THE EQUATION FOR THE SIMULATION
C H - THE DISTANCE BETWEEN NODES (CORRESPONDS TO THE -H- IN THE
C STUDY PLAN)
C
C-----COMPUTE THE DENSITY OF THE SNOWPACK (THE FUNCTION WAS DERIVED FROM
C-----OBSERVED CONDITIONS ON THE FRASER EXPERIMENTAL FOREST)
DENSITY = (EXP((0.019 * PREWEQV) + 3.02))/100.0
C-----COMPUTE THE DISTANCE BETWEEN THE TWO NODES IN CENTIMETERS

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C-----DEPTH = PREWEQV/DENSITY
C-----H = (DEPTH/2)*2.54
      H = (PREWEQV/DENSITY) * 1.27
C-----THE THERMAL DIFFUSIVITY IS CALCULATED FROM THE FUNCTION
C-----KV = 0.01/(12.751 - DENSITY)*0.48). MATHEMATICAL STABILITY
C-----REQUIRES THAT THE VALUE OF THE QUANTITY (INTERVAL IN SECONDS *
C-----KV/H**2) BE LESS THAN 0.5. WHEN A 24 HOUR INTERVAL IS USED, THE
C-----SNOW DEPTH MUST EXCEED 30 INCHES (20 PERCENT DENSITY) TO ACHIEVE
C-----STABILITY. IN ORDER TO INSURE STABILITY WITH SOMEWHAT SHALLOWER
C-----PACKS (ABOUT 18 INCHES), THE DAY IS DIVIDED INTO 2 TIME INTERVALS
C-----OF 12 HOURS (43200 SECONDS)
C-----CONST1 = (43200 * 0.01/(12.751 - DENSITY) * 0.48))/H**2
      CONST1 = 900.0/(12.751 - DENSITY)*H**2
C-----THE MINIMUM WATER EQUIVALENT WHICH WILL ACHIEVE STABILITY USING
C-----THE ABOVE DENSITY FUNCTION IS 4.7 INCHES
      IF(CONST1 - 0.5) 20,10,10
C-----THE MODEL IS UNSTABLE - INDICATE THAT IT IS NOT READY FOR USE NOW.
C-----IT MAY BE INITIALIZED AGAIN BY AN OBSERVED PACK TEMPERATURE CARO
C-----AND STABILITY WILL BE ASCERTAINED FROM THE WATER EQUIVALENT AT
C-----THAT TIME)
      10 OREADY = 0
      RETURN
C-----GET THE SECONO CONSTANT
      20 CONST2 = 1.0 - CONST1 - CONST1
C-----PERFORM THE SIMULATION IN TWO PARTS (ONE FOR EACH 12 HOUR PERIOD).
C-----SIMTEM1- MOLOS THE THREE TEMPERATURES FROM THE PREVIOUS INTERVAL
C-----THAT ARE NEEDED TO SIMULATE SIMTEM2, THE MOODE AT THE CENTER OF
C-----THE PACK. SIMULATE THE FIRST 12 HOURS NOW
      SIMTEM2 = (CONST1 * (SIMTEM1(1) + SIMTEM1(3))) + (CONST2 * SIMTEM1
1(2))
C-----THE AVERAGE SNOWPACK TEMPERATURE IS THE AVERAGE OF THE 2 NODES
C-----[MOODE AND GROUND] IN BOTH INTERVALS. GROUND TEMPERATURE IS
C-----CONSTANT, SO START THE AVERAGE NOW
      SIMTEM3 = SIMTEM1(3) + SIMTEM1(3) + SIMTEM2
C-----RESET -SIMTEM1- TO THE TEMPERATURES OF THE INTERVAL JUST SIMULATED
C-----FOR USE IN THE SECOND 12 HOUR INTERVAL SIMULATION. THE SURFACE
C-----AIR TEMPERATURE IS SPLIT INTO A LOW AVERAGE ( (MEAN+MIN)/2 ) AND
C-----A HIGH AVERAGE ( (MEAN+MAX)/2 ) FOR USE WITH THE TWELVE HOUR
C-----INTERVALS. USE THE LOW AVERAGE NOW
      SIMTEM1(1) = AMIN1 (0.0,((ITEMPLIN-32.0)*0.555555556)+AVETEMC)/
1 2.0)
      SIMTEM1(2) = SIMTEM2
C-----SIMULATE THE SECONO 12 HOURS AND COMPUTE THE AVERAGE SNOWPACK
C-----TEMPERATURE
      SIMTEM2 = (CONST1 * (SIMTEM1(1) + SIMTEM1(3))) + (CONST2 * SIMTEM1
1(2))
      SIMTEM3 = (SIMTEM3 + SIMTEM2)/4.0
C-----RESET -SIMTEM1- USING THE HIGH AVERAGE FOR USE ON THE FIRST
C-----INTERVAL OF THE NEXT DAY
      SIMTEM1(1) = AMIN1 (0.0,((ITEMPMAX-32.0)*0.555555556)+AVETEMC)/
1 2.0)
      SIMTEM1(2) = SIMTEM2
C-----CHECK TO SEE IF THE GROUND TEMPERATURE SHOULD BE RAISED
      IF(SIMTEM3 + 1.5) 60,40,30
      30 IF(SIMTEM3 + 0.5) 40,50,50
      40 IF(SIMTEM1(3).LT.-0.5) SIMTEM1(3) = -0.5
      RETURN
      50 SIMTEM1(3) = 0.0
      60 RETURN
      ENO

```

Subroutine EVTRAN

```

SUBROUTINE EVTRAN
C-----COMPUTE THE EVAPORATION AND TRANSPIRATION DURING THE GROWING
C-----SEASON
C-----
C-----DICTIONARY
C-----AVABLE - THE FACTOR FOR ADJUSTING THE EVAPOTRANSPIRATION FOR
C-----AVAILABLE SOIL WATER
C-----CANREF - THE FACTOR FOR ADJUSTING THE EVAPOTRANSPIRATION
C-----FOR CANOPY REFLECTIVITY
C-----
COMMON/ONLYCOR/ AVETEMC,BASTEMF,CALOEFC,COMAX,COVOEN,DREAOY,ENGBAL,
1 ENGBAL,FREEMAT,LASTUSO,NOAYSNO,ONTREES,PHASE,PREWEQV,RECHRG,
2 SIMTEM1(3),SIMTEM3,TCOEFF,THRSLO,VEGTYPE
INTEGER OREAOY,PHASE,VEGTYPE
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RADIN,RAOLWN,RAOSWN,
1 TEMPMAX,TEMPMIN,WATERIN
ETFROM = 4.0
C-----GET THE ADJUSTMENT FACTOR FOR AVAILABLE SOIL WATER. IF THE
C-----RECHARGE REQUIREMENTS ARE SATISFIED (I.E., FIELD CAPACITY HAS
C-----BEEN REACHED), MAXIMIZE THE ADJUSTMENT FACTOR
      IF(RECHRG) 20,20,10
      10 AVABLE = 1.0
      GO TO 80
C-----IN FORESTED AREAS, USE THE MAXIMIZED FACTOR UNTIL THE RECHARGE
C-----REQUIREMENTS ARE HALF OF THE FIELD CAPACITY. AT THAT POINT, USE
C-----THE LINEAR FUNCTION Y = MX + B, WHERE B = 0.0 TO GET THE FACTOR
      20 IF(COVOEN) 50,50,30
      30 IF(RECHRG + 2.65) 40,10,10
      40 AVABLE = 0.377 * (5.3 + RECHRG)
      GO TO 80
C-----IN CLEARINGS, ASSUME THAT EVAPOTRANSPIRATION DECREASES LINEARLY
C-----FROM THE MAXIMIZED VALUES AT FIELD CAPACITY TO ZERO AT
C-----THREE-FOURTHS OF FIELD CAPACITY
      50 IF(RECHRG + 1.325) 70,70,60
      60 AVABLE = (0.755 * (5.3 + RECHRG)) - 3.0
      GO TO 80
      70 EVAPOTR = 0.0
      RETURN
C-----COMPUTE THE FACTOR FOR ADJUSTING THE EVAPOTRANSPIRATION FOR CANOPY
C-----REFLECTIVITY (PROTECT AGAINST DIVISION BY ZERO - JUST DEFINE THE
C-----FACTOR FOR CLEARINGS AS THE MINIMUM VALUE)

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      80 IF(COMAX) 90,90,100
      90 CANREF = 0.5
      GO TO 130
C-----COMPARE THE COVER DENSITY WITH THE MAXIMUM (CHECK FOR THINNING)
      100 IF(COVOEN - (COMAX/3.0)) 110,110,120
C-----FOR COVER DENSITIES THINNED TO ONE-THIRD OF THE MAXIMUM OR LESS,
C-----USE THIS RELATIONSHIP
      C-----CANREF = 1.0 - (0.5 - ((0.75*CO)/COMX))
      110 CANREF = 0.5 + ((0.75 * COVEN)/COMAX)
      GO TO 130
C-----FROM MAXIMUM COVER DENSITY DOWN TO ONE-THIRD OF THAT VALUE, USE
C-----THE FOLLOWING RELATIONSHIP
      C-----CANREF = 1.0 - (0.25 - ((0.15/(0.67*COMX))*(CO-(0.33*COMX))))
      120 CANREF = 0.75 + ((0.15/(0.67 * COMAX))*(COVEN - (0.33 * COMAX)))
C-----PERFORM THE ADJUSTMENTS
      130 EVAPOTR = EVAPOTR * AVABLE * CANREF
C-----SEE IF THE EVAPOTRANSPIRATION WILL DEplete THE MANTLE STOARGE
C-----BELOW THE WILTING POINT. IF SO, ALTER THE EVAPOTRANSPIRATION
C-----ACCORDINGLY
      IF(RECHRG - EVAPOTR + 5.3) 140,150,150
      140 EVAPOTR = RECHRG + 5.3
      RECHRG = -5.3
      RETURN
      150 RECHRG = RECHRG - EVAPOTR
      RETURN
      ENO

```

Subroutine LINK

```

SUBROUTINE LINK (CALAIR,CALORIE,IRETURN)
C-----THIS SUBROUTINE IS THE INTERFACE BETWEEN THE RADIATION BALANCE
C-----[SUBROUTINE RAOBAL] AND THE DIFFUSION MODEL [SUBROUTINE DIFMOO]
C-----
C-----DICTIONARY
C-----CALDM - THE CALORIC LOSS OF GAIN AS COMPUTED BY THE DIFFUSION
C-----MODEL
C-----
COMMON/ONLYCOR/ AVETEMC,BASTEMF,CALOEFC,COMAX,COVOEN,DREAOY,ENGBAL,
1 ENGBAL,FREEMAT,LASTUSO,NOAYSNO,ONTREES,PHASE,PREWEQV,RECHRG,
2 SIMTEM1(3),SIMTEM3,TCOEFF,THRSLO,VEGTYPE
INTEGER OREAOY,PHASE,VEGTYPE
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RADIN,RAOLWN,RAOSWN,
1 TEMPMAX,TEMPMIN,WATERIN
C-----SEE IF THE RADIATION BALANCE IS AN ENERGY LOSS OR GAIN
      IF(CALORIE) 10,10,80
C-----THERE WAS A LOSS. IF THIS IS STILL WINTER (NO FREE WATER), JUST
C-----GO AHEAD AND USE THE DIFFUSION MODEL
      10 IF(FREEMAT) 20,20,50
C-----USE THE DIFFUSION MODEL TO SIMULATE THE CURRENT AVERAGE SNOWPACK
C-----TEMPERATURE
      20 IF(OREADY.NE.1) GO TO 140
      CALL DIFMOO
      IF(OREADY) 40,40,30
C-----NOW MAKE ANY NECESSARY ADJUSTMENTS IN THE RADIATION BALANCE TO
C-----CAUSE THE PACK TEMPERATURE TO BE THE SAME AS -SIMTEM3-. GET THE
C-----DIFFERENCE BETWEEN THE CALORIE DEFICITS AS COMPUTED BY THE
C-----DIFFERENT METHODS
      30 CALOM = CALOEFC + (SIMTEM3 * PREWEQV * 1.27)
C-----ADJUST THE LONG WAVE PORTION OF THE RADIATION BALANCE BY THE
C-----DIFFERENCE BETWEEN THE CALORIES DERIVED FROM THE DIFFUSION MODEL
C-----AND THE ENERGY BALANCE
      CALORIE = CALOM
      RAOLWN = CALORIE - RAOSWN
      40 IRETURN = 0
      RETURN
C-----THE LOSS IS USED TO FREEZE PART OR ALL OF THE FREE WATER, BUT IT
C-----MAY NOT CREATE COLO CONTENT. IF IT WOULD CREATE COLO CONTENT,
C-----RE-INITIALIZE THE DIFFUSION MODEL TO 0 AND ADJUST THE ENERGY
C-----BALANCE ACCORDINGLY
      50 CALL CALOSS (CALORIE)
      IF(FREEMAT - 0.05) 60,60,70
      60 SIMTEM1(1) = AMIN1 (AVETEMC,0.0)
      SIMTEM1(2) = 0.0
      SIMTEM1(3) = 0.0
      OREADY = 1
C-----MAKE ANY NECESSARY ADJUSTMENTS TO THE ENERGY BALANCE TO COMPENSATE
C-----FOR THE COLO CONTENT THAT WOULD HAVE BEEN GENERATED BY THIS LOSS
C-----AND ZERO THE COLO CONTENT
      ENGBAL = ENGBAL + CALOEFC
      RAOLWN = RAOLWN + CALOEFC
      FREEMAT = 0.0
      CALOEFC = 0.0
      70 IRETURN = 1
      RETURN
C-----THERE IS CALORIC INPUT TO THE PACK. CHECK TO SEE IF CONOITIONS
C-----INDICATE THAT THE DIFFUSION MODEL SHOULD BE TURNED OFF AND THE
C-----ENERGY BALANCE USED FOR SPRINGTIME SIMULATION. CONSIDER FIRST
C-----ANY COLO CONTENT (INCLUDING THAT OF THE PREVIOUS DAY AND ANY
C-----CREATED BY A SNOW EVENT ON THIS DAY). IF THERE IS COLO CONTENT,
C-----CHECK THE AVERAGE AIR TEMPERATURE AND THE SNOWPACK TEMPERATURE
C-----FROM THE PREVIOUS DAY FOR ARBITRARILY CHOSEN SPRINGTIME
C-----CONDITIONS AND IF ALL ARE NOT SATISFIED, GO AHEAD AND USE THE
C-----DIFFUSION MODEL
      80 IF(CALOEFC) 170,170,90
C-----0.889 = 1.27 * 0.7 DEGREES C (ARBITRARY TEMP)
      90 IF(AVETEMC.LE.0.0,OR.CALOEFC.GT.PREWEQV*0.889) GO TO 20
C-----SINCE SPRINGTIME CONOITIONS PREVAIL, RECOMPUTE THE BACK RADIATION
C-----AND THE NET RADIATION BALANCE (REMEMBER, IF THERE IS SNOW, THE
C-----LONGWAVE IS ASSUMED TO BE ZERO, SO THERE WOULD BE NO NEED TO MAKE
C-----ANY ADJUSTMENTS)
      IF(NOAYSNO) 140,140,100
      100 USE = (ITEMPLIN - 32.0) * 0.555555556
      IF(USE.GT.0.0) USE = 0.0

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CALSNOV = 1.17E-7 * ((USE + 273.16) ** 4)
IF(PRECIPI) 110,110,120
110 RAOLWN = ((1.0 - COVOEN) * ((0.757 * CALAIR) - CALSNOW)) + (COVOEN
1 * (CALAIR - CALSNOW))
GO TO 130
120 RAOLWN = CALAIR - CALSNOW
130 CALORIE = RADSWN + RAOLWN
C-----RE-INITIALIZE THE DIFFUSION MODEL TO THESE CONOITIONS (BUT IF THE
C----- INPUT IS MORE THAN ENOUGH TO WIPE OUT THE CALORIE DEFICIT, JUST
C----- LET IT BRING THE PACK TO ISOTHERMAL. IN THIS WAY, TWO CONSECUTIVE
C----- TIVE DAYS OF INPUT ARE REQUIRED TO GENERATE FREE WATER)
140 COMPARE = CALORIE - CALOEF
IF(COMPARE) 160,150,150
C-----INITIALIZE THE DIFFUSION MODEL TO ISOTHERMAL CONDITIONS
150 SIMTEM1(1) = 0.0
SIMTEM1(2) = 0.0
SIMTEM1(3) = 0.0
SIMTEM3 = 0.0
OREADY = 1
GO TO 3D
C-----REDEFINE THE SURFACE TEMPERATURE AND COMPUTE THE NEW AVERAGE PACK
C----- TEMPERATURE. THEN COMPUTE THE MIDDLE NOOE AS A FUNCTION OF THAT
C----- AVERAGE, THE SURFACE TEMPERATURE AND THE GROUND TEMPERATURE
C----- (WHICH REMAINED UNCHANGED)
160 SIMTEM1(1) = AMINI (0.0,AVETEMC)
SIMTEM3 = COMPARE/(PREWEQV * 1.27)
SIMTEM1(2) = (3.0 * SIMTEM3) - SIMTEM1(1) - SIMTEM1(3)
SIMTEM1(3) = 0.0
OREADY = 1
GO TO 3D
C-----THERE IS INPUT TO THE PACK AND THE PACK IS ALREADY ISOTHERMAL. IF
C----- THIS ENERGY WILL CREATE AT LEAST 0.05 INCH (ARBITRARY AMOUNT) OF
C----- FREE WATER, SET THE DIFFUSION MODEL TO STANDBY STATUS AND LET THE
C----- ENERGY BALANCE TAKE ITS COURSE
17D IF(FREWAT + (CALORIE/203.2) - 0.05) 150,180,18D
180 OREADY = 0
IRETURN = D
RETURN
END

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Subroutine MIXTURE

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SUBROUTINE MIXTURE
C-----THIS SUBROUTINE CONTROLS THE COMPUTATIONS FOR A PRECIPITATION
C----- EVENT THAT IS A MIXTURE OF SNOW AND RAIN
C-----
COMMON/ONLYCDR/ AVETEMC,BASTEMF,CALOEF,COMAX,COVOEN,OREADY,ENGBAL,
1 ENGBALL,FREWAT,LASTUSD,NOAYSNO,ONTREES,PHASE,PREWEQV,RECHRG,
2 SIMTEM1(3),SIMTEM3,TCOEFF,THRSHLO,VEGTYP
INTEGER OREADY,PHASE,VEGTYP
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RADIN,RAOLWN,RAOSWN,
1 TEMPMAX,TEMPMIN,WATERIN
C-----DICTIONARY
C-----
C AMTRAIN - THE AMOUNT OF PRECIPITATION OCCURRING AS RAIN
C TFORAIN - THE TEMPERATURE FOR COMPUTING THE DEPLETION OF THE TOTAL
C CALORIE DEFICIT CAUSED BY THE RAIN (DEGREES C)
C TFORSNU - THE TEMPERATURE FOR COMPUTING THE CONTRIBUTION OF THE
C SNOW TO THE TOTAL CALORIE DEFICIT (DEGREES C)
C-----
C-----COMPUTE THE AMOUNT OF PRECIPITATION OCCURRING AS RAIN
C----- AMOUNT RAIN = P * (B/A), WHERE
C----- P = PRECIPITATION IN INCHES
C----- B = DAILY MAXIMUM TEMPERATURE - BASE TEMPERATURE (DEGREES F)
C----- A = DAILY MAXIMUM TEMPERATURE - MINIMUM TEMPERATURE (DEGREES F)
B = TEMPMAX - BASTEMF
A = TEMPMAX - TEMPMIN
AMTRAIN = PRECIP * (B/A)
C-----NOW COMPUTE THE AVERAGE TEMPERATURES (DEGREES C) WHICH PRODUCE
C----- SNOW AND RAIN
TFORSNO = (TEMPMIN + BASTEMF - 64.0) * 0.277777777B
TFORAIN = (TEMPMAX + BASTEMF - 64.0) * 0.277777777B
C-----COMPUTE THE EFFECT OF THE SNOW ON THE SNOWPACK
CALL SNOWED (TFORSNO,PRECIP-AMTRAIN)
C-----COMPUTE THE EFFECT OF THAT PORTION OF THE PRECIPITATION OCCURRING
C----- AS RAIN ON THE SNOWPACK
CALL RAINED (TFORAIN,AMTRAIN)
RETURN
END

```

Function PACKREF

```

FUNCTION PACKREF (OUMMY)
C-----GET THE REFLECTIVITY OF THE SNOWPACK
COMMON/ONLYCDR/ AVETEMC,BASTEMF,CALOEF,COMAX,COVOEN,OREADY,ENGBAL,
1 ENGBALL,FREWAT,LASTUSD,NOAYSNO,ONTREES,PHASE,PREWEQV,RECHRG,
2 SIMTEM1(3),SIMTEM3,TCOEFF,THRSHLO,VEGTYP
INTEGER OREADY,PHASE,VEGTYP
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RADIN,RAOLWN,RAOSWN,
1 TEMPMAX,TEMPMIN,WATERIN
C-----
C-----DICTIONARY
C-----
C PASTINT - A VARIABLE SET EQUAL TO -NOAYSNO- AND ALTERED AS NEEDED
C TO CHOOSE THE PROPER REFLECTIVITY FUNCTION
C REFACUM - A REFLECTIVITY FUNCTION FOR THE SNOWPACK DURING THE
C ACCUMULATION PHASE OF THE SNOWPACK
C REFELT - A REFLECTIVITY FUNCTION FOR THE SNOWPACK DURING THE
C MELT PHASE OF THE SNOWPACK
C-----
DIMENSION REFACUM(15),REFELT(15)
INTEGER PASTINT
DATA REFACUM/.80, .77, .75, .72, .7D, .69, .68, .67, .66, .65,

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1 .64, .63, .62, .61, .60/
DATA REFELT/.72, .65, .60, .58, .56, .54, .52, .50, .48, .46,
1 .44, .43, .42, .41, .40/
PASTINT = NOAYSNO
IF(NOAYSNO) 8D,8D,10
C-----USE THE SAME FUNCTION AS LAST TIME
10 IF(LASTUSD) 20,2D,5D
C-----ACCUMULATION PHASE - AFTER 15 DAYS, USE THE MELT FUNCTION
C----- STARTING AT THE FOURTH DAY
20 IF(PASTINT - 15) 30,30,4D
30 PACKREF = REFACUM(PASTINT)
RETURN
40 PASTINT = PASTINT - 11
C-----MELT FUNCTION - AFTER 15 DAYS, USE A CONSTANT 40 PERCENT
50 IF(PASTINT - 15) 70,70,6D
60 PASTINT = 15
70 PACKREF = REFELT(PASTINT)
RETURN
C-----THERE IS NEW SNOW - DETERMINE IF THE FUNCTION IS TO BE RE-
C----- INITIALIZED
8D IF(TEMPMAX - THRSHLO) 90,90,10
C-----IT IS, SO SEE WHICH FUNCTION IS TO BE USED
90 IF(CALOEF) 110,110,10D
100 PACKREF = 0.91
LASTUSD = 0
RETURN
C-----THE PACK IS ISOTHERMAL, BUT IF THE ENERGY BALANCE FROM THE
C----- PREVIOUS INTERVAL WAS NEGATIVE, USE THE ACCUMULATION PHASE
C----- FUNCTION ANYWAY
11D IF(ENGBAL) 100,120,12D
120 PACKREF = 0.81
LASTUSD = 1
RETURN
END

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Subroutine RADBAL

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SUBROUTINE RADBAL
C-----THIS SUBROUTINE COMPUTES THE RADIATION BALANCE AND TRANSFERS
C----- CONTROL TO THE DIFFUSION MODEL IF IT IS NEEDED
COMMON/ONLYCDR/ AVETEMC,BASTEMF,CALOEF,COMAX,COVOEN,OREADY,ENGBAL,
1 ENGBALL,FREWAT,LASTUSD,NOAYSNO,ONTREES,PHASE,PREWEQV,RECHRG,
2 SIMTEM1(3),SIMTEM3,TCOEFF,THRSHLO,VEGTYP
INTEGER OREADY,PHASE,VEGTYP
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RADIN,RAOLWN,RAOSWN,
1 TEMPMAX,TEMPMIN,WATERIN
C-----
C-----DICTIONARY
C-----
C CALAIR - POTENTIAL LONGWAVE CALORIC INPUT AT AIR TEMPERATURE
C CALORIE - CALORIES OF HEAT ABSORBED OR RELEASED BY THE SNOWPACK
C FROM THE NET RADIATION BALANCE
C CALSNOW - POTENTIAL LONGWAVE CALORIC LOSS AT SNOW TEMPERATURE
C SNOCAN - THE LONGWAVE RADIATION BALANCE BETWEEN THE SNOW AND THE
C CANOPY
C SNOISKY - THE LONGWAVE RADIATION BALANCE BETWEEN THE SNOW AND THE
C SKY
C-----COMPUTE THE CALDRIC INPUT FROM NET SHORT WAVE RADIATION AS A
C----- FUNCTION OF THE SNOWPACK REFLECTIVITY
RAOSWN = RADIN * (1.0 - PACKREF (0.0)) * TCOEFF
C-----IF THE PACK IS ACCUMULATING, BUT IS NOT DEEP ENOUGH FOR STABILITY
C----- IN THE DIFFUSION MODEL, USE THE FOLLOWING SIMPLIFIED METHOD FOR
C----- DERIVING THE RADIATION BALANCE
IF(PHASE) 60,10,10D
10 IF(PREWEQV - 4.7) 2D,5D,5D
C-----USE ONLY THE SHORTWAVE INPUT (THIS IMPLIES THAT THE ONLY COLO
C----- CONTENT GENERATED IN THE ACCUMULATING PACK IS THAT OF NEW SNOW)
20 CALORIE = RAOSWN
RAOLWN = 0.0
CALL CALIN (CALORIE)
C-----IF THE MEAN TEMPERATURE WAS LESS THAN OR EQUAL TO 0 C, DO NOT
C----- ALLOW ANY MELT OR FREE WATER
IF(AVETEMC) 30,30,4D
30 PREWEQV = PREWEQV + WATERIN
RAOLWN = -ENGBAL
ENGBAL = 0.0
WATERIN = 0.0
FREWAT = 0.0
CALOEF = 0.0
40 RETURN
C-----THE PACK HAS JUST REACHED A SUFFICIENT DEPTH. INITIALIZE THE
C----- DIFFUSION MODEL, BUT RETAIN PSEUDO-CONTROL UNTIL THE DIFFUSION
C----- MODEL IS WELL ALONG INTO STABLE CONTROL
50 PHASE = -1
OREADY = 1
C-----START THE PACK AT -3 C (CAL OEF = PACK TEMP * PREWEQV * 1.27)
C----- CALOEF = 3.81 * PREWEQV
RAOLWN = - CALOEF - RAOSWN - ENGBAL
ENGBAL = - CALOEF
SIMTEM1(1) = AMINI (AVETEMC,0.0)
SIMTEM1(2) = -3.0
SIMTEM1(3) = -1.5
FREWAT = 0.0
RETURN
C-----THE DIFFUSION MODEL HAS BEEN INITIALIZED PREVIOUSLY. IF IT IS
C----- STILL STABLE AND IF THE PACK IS DEEP ENOUGH TO ENSURE CONTINUED
C----- STABILITY UNTIL MELT, RELINQUISH CONTROL COMPLETELY TO THE
C----- NORMAL METHOD OF COMPUTING THE RADIATION BALANCE, INTERFACED WITH
C----- THE DIFFUSION MODEL
60 IF(OREADY) 100,70,8D
70 PHASE = 0
GO TO 10
80 CALORIE = RAOSWN

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CALAIR = 0.0
RADLWN = 0.0
1FIPREWEQV = 5.0) 160,160,90
90 PHASE = 1
C-----USE THE NORMAL METHOD OF COMPUTING THE RADIATION BALANCE. IF ANY
C-----AND SNOW TEMPERATURES TO POTENTIAL CALORIES BY THE STEFAN -
C-----BLOTZMANN FUNCTION, CALORIES = S * (T ** 4), WHERE
C-----S = 1.17E-7 CAL/(CM**2)(DEGREES KELVIN)**4), AND
C-----T = ABSOLUTE TEMPERATURE (DEGREES KELVIN)
120 CALAIR = 1.17E-7 * ((AVETEMC + 273.16) ** 4)
USE = AVETEMC
C-----IF THE SNOWPACK IS ISOTHERMAL, USE THE MINIMUM TEMPERATURE FOR
C-----COMPUTING THE BACK RADIATION
1F(CALDEF.EQ.0.0) USE = (TEMPMIN - 32.0) * 0.5555555556
C-----UNDER NO CIRCUMSTANCES MAY THE TEMPERATURE FOR COMPUTING THE BACK
C-----RADIATION BE GREATER THAN ZERO
1F(USE.GT.0.0) USE = 0.0
CALSNOW = 1.17E-7 * ((USE + 273.16) ** 4)
C-----COMPUTE THE LONG WAVE RADIATION COMPONENTS AS A FUNCTION OF THE
C-----FIRST, DETERMINE WHETHER THE SKIES ARE CLEAR OR CLOUDY
1F(PRECIP) 130,130,140
C-----WITH CLEAR SKIES, THE DOWNWARD LONGWAVE RADIATION COEFFICIENT IS
C-----0.757 (RUNOFF FROM SNOWMELT, EMILLD-2-1406, US ARMY CORPS OF
C-----ENGINEERS, 1960, PAGE 7)
130 SNOSKY = (1.0 - COVDEN) * (10.757 * CALAIR) - CALSNOW
C-----THE DOWNWARD LONGWAVE RADIATION COEFFICIENT IS 1.0 BENEATH THE
C-----FOREST CANOPY (OR BENEATH CLOUDY SKIES)
SNOCAN = COVDEN * (CALAIR - CALSNOW)
RADLWN = SNOCAN + SNOSKY
GO TO 150
C-----WITH CLOUDY SKIES, WHEN THE DOWNWARD LONGWAVE RADIATION COEFFI-
C-----CIENT IS 1.0 INSTEAD OF .757, THE ABOVE THREE EQUATIONS MAY BE
C-----REDUCED ALGEBRAICALLY TO THE FOLLOWING SINGLE EQUATION
140 RADLWN = CALAIR - CALSNOW
C-----COMPUTE THE CALORIC INPUT OR LOSS FROM THE NET EFFECT OF SHORT
C-----WAVE AND LONG WAVE RADIATION
150 CALORIE = RADSWN + RADLWN
C-----THE SNOWPACK TEMPERATURE DIFFUSION MODEL (LEAF, 1970, STUDY PLAN
C-----FS-RW-1602, NO. 224, ROCKY MOUNTAIN FOREST AND RANGE EXP STA) IS
C-----INCORPORATED TO CONTROL THE SNOWPACK TEMPERATURE AND COLD CONTENT
C-----DURING NON-ISOTHERMAL CONDITIONS. SEE NOW IF THE DIFFUSION MODEL
C-----MAY BE USED (READY MAY NOT BE -1 AND PASS THROUGH LINK SINCE IT
C-----IS NOT DESIGNED TO WORK WITH IT. THE -1 IS USED TO INDICATE THAT
C-----THE RADIATION ROUTINES ARE TO BE USED EXCLUSIVELY). IF IT MAY BE
C-----USED, PASS THROUGH THE LINKING ROUTINE WHICH INTERFACES THE
C-----DIFFUSION MODEL AND THE RADIATION ROUTINES
1F(OREADY) 170,160,160
160 CALL LINK (CALAIR,CALORIE,IRETURN)
1F(IRETURN) 170,170,190
170 1F(CALORIE) 180,190,200
180 CALL CALOSS (CALORIE)
190 RETURN
200 CALL CALIN (CALORIE)
RETURN
END

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Subroutine RAINED

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SUBROUTINE RAINED (TFORAIN,AMTRAIN)
C-----THIS SUBROUTINE COMPUTES THE EFFECT OF RAIN ON SNOW
COMMON/ONLYCOR/ AVETEMC,BASTEMF,CALDEF,COMAX,COVDEN,OREADY,ENGBAL,
1 ENGBAL1,FREEWAT,LASTUSO,NOAYSNO,ONTREES,PHASE,PREWEQV,RECHRG,
2 SIMTEM1(3),SIMTEM3,TCOEFF,THRSHLD,VEGTYPE
INTEGER OREADY,PHASE,VEGTYPE
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RADIN,RADLWN,RADSWN,
1 TEMPMAX,TEMPMIN,WATERIN
C-----
C-----DICTIONARY
C CALRAIN - THE AMOUNT OF PRECIPITATION OCCURRING AS RAIN (INCHES)
C CALRAIN - THE DEPLETION OF THE TOTAL CALORIE DEFICIT BY THIS RAIN
C (CALORIES)
C TFORAIN - THE TEMPERATURE FOR COMPUTING THE DEPLETION OF THE TOTAL
C CALORIE DEFICIT CAUSED BY THIS RAIN (DEGREES C)
C-----
C-----ADD THIS AMOUNT OF PRECIPITATION TO THE PREDICTED WATER EQUIVALENT
PREWEQV = PREWEQV + AMTRAIN
C-----SEE IF THERE IS A CALORIE DEFICIT IN THE PACK
1F(CALDEF) 50,50,10
C-----COMPUTE THE AMOUNT OF RAIN AT THIS TEMPERATURE THAT IS NEEDED TO
C-----WIPE OUT THE DEFICIT AND COMPARE IT WITH THE ACTUAL AMOUNT
10 CALRAIN = (80.0 + TFORAIN) * 2.54
AMTNEED = CALDEF/CALRAIN
COMPARE = AMTRAIN - AMTNEED
1F(COMPARE) 30,20,40
C-----THERE WAS JUST ENOUGH TO WIPE OUT THE DEFICIT
20 CALDEF = 0.0
ENGBAL = ENGBAL + CALRAIN
RETURN
C-----THERE WAS NOT ENOUGH TO WIPE IT OUT COMPLETELY. JUST DEplete
C-----THE DEFICIT
30 CALDEF = CALDEF - (CALRAIN * AMTRAIN)
ENGBAL = ENGBAL + (CALRAIN * AMTRAIN)
RETURN
C-----THERE WAS MORE THAN ENOUGH TO WIPE OUT THE DEFICIT. THE AMOUNT
C-----OF RAIN NOT FROZEN IS FREE WATER
40 FREEWAT = COMPARE
CALL CALIN (TFORAIN * COMPARE * 2.54)
RETURN

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C-----ALL OF THE RAIN IS ADDED TO THE FREE WATER AND CONTRIBUTES CALORIC
C-----INPUT TO THE PACK
50 FREEWAT = FREEWAT + AMTRAIN
CALL CALIN (TFORAIN * AMTRAIN * 2.54)
RETURN
END

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Subroutine SNOWED

```

SUBROUTINE SNOWED (TFORSNO,AMTSNOW)
C-----THIS SUBROUTINE COMPUTES THE EFFECTS OF A SNOW EVENT ON THE
C-----SNOWPACK
COMMON/MASTER/DATE(3),THXSTR,THNMSTR,PPTMSTR,PPTONOW,OBSHYDR,
1 POTRAD,MSTREOF,IYR
INTEGER DATE
COMMON/ONLYCOR/ AVETEMC,BASTEMF,CALDEF,COMAX,COVDEN,OREADY,ENGBAL,
1 ENGBAL1,FREEWAT,LASTUSO,NOAYSNO,ONTREES,PHASE,PREWEQV,RECHRG,
2 SIMTEM1(3),SIMTEM3,TCOEFF,THRSHLD,VEGTYPE
INTEGER OREADY,PHASE,VEGTYPE
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RADIN,RADLWN,RADSWN,
1 TEMPMAX,TEMPMIN,WATERIN
REAL INTRCPT
C-----
C-----DICTIONARY
C AMTSNOW - THE AMOUNT OF PRECIPITATION OCCURRING AS SNOW (INCHES)
C CALSNOW - THE CONTRIBUTION OF THIS SNOW TO THE TOTAL CALORIE
C DEFICIT (CALORIES)
C INTRCPT - THE AMOUNT OF SNOW INTERCEPTED DURING THIS PRECIP EVENT
C TFORSNO - THE TEMPERATURE FOR COMPUTING THE CONTRIBUTION OF THIS
C SNOW TO THE TOTAL CALORIE DEFICIT (DEGREES C)
C-----
C-----DO NOT ALLOW ANY INTERCEPTION IN JULY AND AUGUST
1F(0ATE(1).EQ.7.OR.0ATE(1).EQ.8) GO TO 10
C-----DETERMINE THE AMOUNT OF INTERCEPTED SNOW AS A FUNCTION OF COVER
C-----COMPOSITION AND COVER DENSITY
1F(COMAX) 10,10,20
10 INTRCPT = 0.0
GO TO 80
20 1F(VEGTYPE - 1) 30,30,40
C-----LOOSEPOLE PINE
30 PERCENT = 0.10
GREATST = 0.20
GO TO 50
C-----SPRUCE FIR
40 PERCENT = 0.15
GREATST = 0.30
50 INTRCPT = AMTSNOW * PERCENT * (COVDEN/COMAX)
1F(ONTREES + INTRCPT - GREATST) 70,70,60
60 INTRCPT = GREATST - ONTREES
70 ONTREES = ONTREES + INTRCPT
80 NOAYSNO = 0
C-----ADD THIS AMOUNT OF PRECIPITATION TO THE PREDICTED WATER EQUIVALENT
PREWEQV = PREWEQV + AMTSNOW - INTRCPT
C-----THE SNOW FALLING WHEN THE TEMPERATURE IS BETWEEN 35 AND 32 DEGREES
C-----DOES NOT ALTER THE CALORIC DEFICIT
1F(TFORSNO.GE.0.0) RETURN
C-----COMPUTE THE CALORIE DEFICIT FOR THIS SNOW BY THE EQUATION
C-----CALORIE DEFICIT = S(1)*DELTA T**P, WHERE
C-----S(1) = SPECIFIC HEAT OF ICE (.5 CAL/CM/DEGREES C),
C-----DELTA T = CHANGE IN TEMPERATURE WITH RESPECT TO FREEZING (0.0
C-----DEGREES CENTIGRADE), AND
C-----P = PRECIPITATION IN CM (CONVERSION FACTOR = 2.54 CM/IN).
C-----THEREFORE, CALORIE DEFICIT = 0.5 * (TFORSNO) * (AMTSNOW * 2.54)
CALL CALOSS (TFORSNO * (AMTSNOW - INTRCPT) * 1.27)
RETURN
END

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Subroutine SNOWVAP

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SUBROUTINE SNOWVAP
C-----COMPUTE THE EVAPORATION FROM THE SURFACE OF THE SNOWPACK AS A
C-----FUNCTION OF THE COVER DENSITY AND REDUCE THE PACK ACCORDINGLY
COMMON/ONLYCOR/ AVETEMC,BASTEMF,CALDEF,COMAX,COVDEN,OREADY,ENGBAL,
1 ENGBAL1,FREEWAT,LASTUSO,NOAYSNO,ONTREES,PHASE,PREWEQV,RECHRG,
2 SIMTEM1(3),SIMTEM3,TCOEFF,THRSHLD,VEGTYPE
INTEGER OREADY,PHASE,VEGTYPE
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RADIN,RADLWN,RADSWN,
1 TEMPMAX,TEMPMIN,WATERIN
ETFROM = 2.0
EVAPOTR = (1.0 - COVDEN) * EVAPOTR
PREWEQV = PREWEQV - EVAPOTR
RETURN
END

```

Subroutine ETCODE

```

SUBROUTINE ETCODE (ETFROM,COMPS12)
C-----KEEP TRACK OF WHICH SOURCES WERE USED FOR EVAPOTRANSPIRATION
1F(ETFROM - 2.0) 10,20,30
C-----EVAPORATION FROM INTERCEPTED SNOW ON CANOPY (ETFROM = 1)
10 1F(COMPS12.NE.1.0.AND.COMPS12.NE.3.0.AND.COMPS12.NE.5.0.AND.
1 COMPS12.NE.7.0) COMPS12 = COMPS12 + ETFROM
RETURN
C-----EVAPORATION FROM SNOWPACK (ETFROM = 2)
20 1F(COMPS12.NE.2.0.AND.COMPS12.NE.3.0.AND.COMPS12.LT.6.0) COMPS12 =
1 COMPS12 + ETFROM
RETURN
C-----EVAPOTRANSPIRATION FROM MELT, PRECIP OR STORAGE (ETFROM = 4)
30 1F(COMPS12.LT.4.0) COMPS12 = COMPS12 + ETFROM
RETURN
END

```


Subroutine GENDATA

```

SUBROUTINE GENDATA (N)
C-----GENERATE THE DATA FOR THIS SUBSTATION
C-----
C-----DICTIONARY
C
C    OD - THE EXACT POINT IN THE DEGREE-DAY TABLE WHICH IS TO BE USED
C          IN THE COMPUTATION OF THE INCOMING RADIATION
C    DOFACT - THE TABLE OF ADJUSTMENTS FACTORS FOR COMPUTING THE
C          INCOMING RADIATION
C    OOI - A REAL, TRUNCATED VALUE OF -OD- USED IN INTERPOLATION
C    ET - THE ADJUSTED POTENTIAL EVAPOTRANSPIRATION (MAINTAINED FOR
C          THE REDEFINITION OF -EVAPOTR- BY THE ALTERNATIVES
C    RADHORZ - THE INCOMING RADIATION COMPUTED FROM THE POTENTIAL AT
C          A HORIZONTAL SURFACE
C
C    COMMON AIRTEMC(25,6)
C    COMMON CALOEF(25),CDMAX(25),COVOEN(25)
C    COMMON DREADY(25)
C    COMMON ENGBAL(25),ET,ETDAILY(25,12)
C    COMMON FREEWAT(25)
C    COMMON ISOTHR(25,20)
C    COMMON LASTUSO(25),LEVEL1,LEVEL2
C    COMMON MMDO
C    COMMON NDAYSNO(25),NOIVSBL,NSUB,NYEARS
C    COMMON ONTREES(25)
C    COMMON PEAKPPT(25,20),PEAKWE(25,20),PHASE(25),POTENT(24),
C    PREWEQV(25)
C    COMMON RECHRG(25)
C    COMMON SIMTEML(25,3),SUBID(25,6),SLPASP(25,24)
C    COMMON TCDEF1(25),THRSHLD(25),TOPLOT(11)
C    COMMON VEGTYPE(25)
C    COMMON WEIGHT1(25),WSHEOID(6)
C    COMMON YEARS(20),YYMMOO
C    INTEGER DREADY
C    INTEGER PHASE
C    INTEGER SUBIO
C    INTEGER TOPLOT
C    (INTEGER VEGTYPE
C    INTEGER WSHEOID
C    INTEGER YEARS,YYMMOO
C    COMMON/MASTER/DATE(13),TMXMSTR,TMNMSTR,PPTMSTR,PPTONOW,OBSHYDR,
C    1 POTRAO,MSTREOF,IYR
C    INTEGER DATE
C    COMMON/RAO/FRACTION,I5UB
C    COMMON/WATBAL/ETFROM,EVAPOTR,GENRD,PRECIP,RAOIN,RAOLWN,RAOSWN,
C    1 TEMPMAX,TEMPMIN,WATERIN
C    EQUIVALENCE (DATE(1),MONTH)
C    DIMENSION DOFACT(6)
C    DATA DOFACT / .20, .35, .45, .51, .56, .59, .62, .64, .655, .67,
C    1 .682, .69, .70, .71, .715, .72, .722, .724, .726, .728, .73,
C    2 .734, .738, .742, .746, .75/
C-----ADJUST THE TEMPERATURES
C    IF(DATE(13) - 67) 10,20,20
C    10 I = 5
C    GO TO 30
C    20 I = 3
C    30 TEMPMIN = AIRTEMC(N,I) + (TMNMSTR * AIRTEMC(N,I+1))
C    TEMPMAX = AIRTEMC(N,I) + (TMXMSTR * AIRTEMC(N,I+2))
C    IF(TEMPMAX,GE,TEMPMIN) GO TO 40
C    XXX = TEMPMAX
C    TEMPMAX = TEMPMIN
C    TEMPMIN = XXX
C-----COMPUTE THE INCOMING RADIATION AT THE BASE STATION FROM THE
C----- POTENTIAL BY THE DEGREE-DAY METHOD
C    40 GO TO (50,50,50,50,60,70,70,70,60,50,50,50),MONTH
C-----OCTOBER - APRIL, DEGREE DAYS = .44 * TEMPMAX - 15.9 (+1.0 FOR
C----- SUBSCRIPTING)
C    50 DO = (0.44 * TEMPMAX) - 14.9
C    GO TO 100
C-----MAY AND SEPTEMBER, DEGREE DAYS = .53 * TEMPMAX - 19.5 (+1.0 FOR
C----- SUBSCRIPTING)
C    60 DO = (0.53 * TEMPMAX) - 18.5
C    GO TO 100
C-----JUNE, JULY AND AUGUST, DEGREE DAYS = .63 * TEMPMAX - 24.1 (+1.0
C----- FOR SUBSCRIPTING), EXCEPT ON DAYS WITH PRECIP. DURING THESE
C----- MONTHS, USE A CONSTANT 44 PERCENT ON PRECIP DAYS
C    70 IF(PPTMSTR) 90,90,80
C    80 RADHORZ = POTRAO * 0.44
C    GO TO 150
C    90 DO = (0.63 * TEMPMAX) - 23.1
C-----WATCH FOR THE BOUNDARY VALUES, 0. AND 25. (WITH THE 1.0 ABOVE)
C----- ABOVE, THE SUBSCRIPTS FOR THE TABULAR VALUES VARY FROM 1 TO 26)
C    100 IF(DO - 1.0) 110,110,120
C-----USE THE FIRST TABLE VALUE (NO INTERPOLATION IS NECESSARY)
C    110 RADHORZ = POTRAO * DOFACT(1)
C    GO TO 150
C    120 IF(DO - 26.0) 140,130,130
C-----USE THE LAST TABLE VALUE (NO INTERPOLATION IS NECESSARY)
C    130 RADHORZ = POTRAO * DOFACT(26)
C    GO TO 150
C-----THE SUBSCRIPT IS IN THE PROPER RANGE. OBTAIN THE INTERPOLATION
C----- FRACTION AND SUBSCRIPTS THROUGH TRUNCATION OF -OD-
C    140 JI = DO
C    OOI = JI
C    J = JI + 1
C-----THE TERM (OOI-ODI)/1.0 IS THE INTERPOLATION FRACTION
C    RADHORZ = POTRAO * (DOFACT(JI) + ((DOFACT(JI) - DOFACT(JI+1)) * (DO -
C    1 OOI)))
C-----WATCH THE POTENTIAL EVAPOTRANSPIRATION AS COMPUTED BY THE HAMON
C----- METHOD FOR AVAILABLE RADIATION AS A PERCENT OF POTENTIAL
C    150 EVAPOTR = ETDAILY(N,MONTH) * (RADHORZ/POTRAO)
C    ET = EVAPOTR
C-----ADJUST THE RADIATION AT THE BASE STATION FOR SLOPE AND ASPECT

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RADIN = RADHORZ * (SLPASP(N,ISUB) + I(SLPASP(N,ISUB+1) - SLPASP(N,
1 ISUB)) * FRAC(TON))
C-----ADJUST THE PRECIP TO ENSURE REACHING THE PEAK WATER EQUIVALENT
1 IF(PPTMSTR) 16D,16D,17D
16D PRECIP = D.0
RETURN
17D IF(PEAKPPT(N,IYR) - PPTONOW) 19D,19D,18D
18D PRECIP = PPTMSTR * ((PEAKWE(N,IYR) - PREWEQV(N)I)/IPEAKPPT(N,IYR)
1 - PPTONOW))
RETURN
19D PRECIP = PPTMSTR
RETURN
END

```

Subroutine PLOTTER

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SUBROUTINE PLOTTER
C ---- PLOT THE INFORMATION. THE NORMAL SCALE IS 20 PRINT POSITIONS = 1
C ---- INCH, BUT SEVERAL OF THE PLOTS HAVE ADDITIONAL SCALE FACTORS AS
C ---- EXPLAINED BELOW TO ENHANCE THEIR VISIBLE REPRESENTATIONS
C ----
C ----DICTIONARY
C
C BOUNDL - THE LOWER BOUNDARY FOR VALUES TO BE PLOTTED IN EACH OF
C THE THREE LEVELS (AND THE PSEUDO FOURTH LEVEL)
C BOUNDU - THE UPPER BOUNDARY FOR VALUES TO BE PLOTTED IN EACH OF
C THE THREE LEVELS (AND THE PSEUDO FOURTH LEVEL)
C LETTER - THE ONE DIGIT SYMBOL TO BE PLOTTED FOR EACH VARIABLE.
C ALL VARIABLES FOR ALTERNATIVES ARE PLOTTED AS -A- AND
C ARE PLOTTED IN THE SAME LEVEL AS THEIR NORMAL
C COUNTERPART TO IDENTIFY THEM
C POINT - THE ARRAY WHICH REPRESENTS ONE LINE ON THE PLOT. IT IS
C DIVIDED INTO THREE LEVELS (INDEPENDENT PLOTS), WITH A
C BASE LINE PRINTING FOR EACH AT POSITIONS 1, 42, 83
C AND 124. THIS LEAVES 40 POSITIONS BETWEEN THE LINES
C FOR PLOTTING PURPOSES
C RAISE - THE QUANTITY NEEDED TO RAISE THE CURVE TO THE PROPER LEVEL
C SCALE - THE SCALING FACTOR FOR EACH OF THE VARIABLES. EACH
C INCLUDES THE NORMAL SCALING FACTOR, 20.0, AND ANY
C OTHER FACTOR DEEMED NECESSARY, AS EXPLAINED BELOW
C TOPLOT - AN ARRAY OF LEVEL INDICATORS FOR EACH VARIABLE TO BE
C PLOTTED. IF IT IS ZERO, THE VARIABLE WILL NOT BE
C PLOTTED. THE VALUE OF TOPLOT MUST BE 1, 2 OR 3 FOR
C ALL VARIABLES EXCEPT STORAGE. SINCE STORAGE IS A
C NEGATIVE VALUE AND PRINTS BELOW THE BASE LINE, IT MAY
C NOT BE PART OF A PART OF THE PLOT. IT MAY, HOWEVER,
C BE ASSIGNED TO THE PSEUDO LEVEL 4, AND THUS WILL
C PRINT BENEATH THE TOP MOST BASE LINE
C

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COMMON AIRTEC(25,6)
COMMON CALOEF(25),COMAX(25),COVDEN(25)
COMMON OREADY(25)
COMMON ENGBAL(25),ET,ETOAILY(25,12)
COMMON FREEWAT(25)
COMMON ISOHRM(25,20)
COMMON LASTUSO(25),LEVEL1,LEVEL2
COMMON MMOD
COMMON NOAYSNOI(25),NDIVSBL,NSUB,NYEARS
COMMON ONTRES(25)
COMMON PEAKPPT(25,20),PEAKWE(25,20),PHASE(25),POTENT(24),
1 PREWEQV(25)
COMMON RECHRG(25)
COMMON SIMTEM1(25,3),SUBIO(25,6),SLPASP(25,24)
COMMON TCoeff(25),THRSHLO(25),TOPLOT(11)
COMMON VEGTYPE(25)
COMMON WEIGHT(25),WSHEOIO(6)
COMMON YEARS(20),YYMMOD
INTEGER OREADY
INTEGER PHASE
INTEGER SUBIO
INTEGER TOPLOT
INTEGER VEGTYPE
INTEGER WSHEOIO
INTEGER YEARS,YYMMOD
COMMON/FORDATA/ FOOTNOT(26),MAXLINE
INTEGER FOOTNOT
COMMON/MASTER/DATE(3),TMXMSR,TMMMSR,PPTMSR,PPTONOW,OBSSHOR,
1 POTRAQ,MSTREOF,IYR
INTEGER OATE
COMMON/PLOTS/PLOT(11)
COMMON/WATBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RAOIN,RAOLWN,RAOSWN,
1 TEMPMAX,TEMPMIN,WATERIN
INTEGER BOUNOL(4),BOUNOU(4),POINT(124)
DIMENSION LETTER(11),RAISE(4),SCALE(11)
EQUIVALENCE (OATE),(1OAY)
DATA BOUNOL,BOUNOU,RAISE(1),42,83,83,42,83,124,124,1.5,42.5,83.5,
1 1.5,5/
DATA POINT(1H,.40*1H,1H,.40*1H,1H,.40*1H,1H,.40*1H)
C-----HYDROGRAPH - MAX VALUE = 0.5, MULTIPLY BY 4 AS WELL AS 20
DATA LETTER(1),SCALE(1)/1H,80.0/
C-----WATER EQUIVALENT - MAX VALUE = 30.0, OIIVOE BY 15 11.33 = 20/15)
DATA LETTER(2),LETTER(7),SCALE(2),SCALE(7)/1H,1HA,2*1.33/
C-----INPUT - MAX VALUE = 2.0, NO EXTRA SCALING NEEDED
DATA LETTER(3),LETTER(8),SCALE(3),SCALE(8)/1H,1HA,2*20.0/
C-----EVAPOTRANSPIRATION - MAX VALUE = 0.5, MULTIPLY BY 4 AND 20
DATA LETTER(4),LETTER(9),SCALE(4),SCALE(9)/1H,1HA,2*80.0/
C-----STORAGE REQUIREMENTS - MIN VALUE = -5.3 (7.547 = 20/(5.3/2))
DATA LETTER(5),LETTER(10),SCALE(5),SCALE(10)/1H,1HA,2*7.547/
C-----RUNOFF - MAX VALUE = 2.0, NO EXTRA SCALING NEEDED
DATA LETTER(6),LETTER(11),SCALE(6),SCALE(11)/1H,1HA,2*20.0/
C-----NOTE EACH OF THESE THAT IS TO BE PLOTTED, RAISE IT TO THE PROPER
C----- LEVEL AND IF IT IS WITHIN THE BOUNDARIES FOR THAT LEVEL, STORE
C----- THE CHARACTER FOR THE PLOT
OO 2D.I = 1,11

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      IF(TOPLLOT(I)) 20,20,10
10  J = TOPLLOT(I)
      IPOINT = (PLOT(I) * SCALE(I)) + RAISE(J)
      IF(1.E0.5.OR.1.E0.10) J = J - 1
      IF(IPOINT.GT.BOUNDL(J).AND.IPOINT.LT.BOUNDOU(J)) POINT(IPOINT) =
      1 LETTER(I)
20  CONTINUE
C-----WRITE THE DATE BY TENS
      IF(10AY.E0.10.OR.10AY.E0.20.OR.10AY.E0.30) GO TO 30
      WRITE (11,910) POINT
910  FORMAT(9X124A1)
      GO TO 40
30  WRITE (11,920) DATE,POINT
920  FORMAT(1X3I2,2H.,124A1)
40  DO 50 I = 2,123
50  POINT(I) = 1H.
      POINT(42) = 1H.
      POINT(83) = 1H.
      RETURN
      END

```

Subroutine RADCOMP

```

      SUBROUTINE RADCOMP
C-----COMPUTE THE POTENTIAL RAOIATION AT THE BASE STATION
C-----
C-----DICTIONARY
C
C   BETWEEN - THE TOTAL NUMBER OF OAYS BETWEEN THE RESPECTIVE
C             LOCATIONS OF THE DATES IN -NOATE-
C   DAYS - THE NUMBER OF DAYS THAT HAVE PASSED SINCE THE BASE DATE
C           I-NOATE(I SUB)- TO BE USED IN THE INTERPOLATION
C   FRACTON - THE FRACTIONAL PART NEEDED IN THE INTERPOLATION BETWEEN
C             TABLE VALUES IN THE COMPUTATION OF THE RADIATION
C   ISUB - THE SUBSCRIPT OF THE BASE TABLE VALUE USED TO OBTAIN THE
C          RADIATION FROM THE TABLES BY INTERPOLATION
C   NOATE - THE OATES OF THE TABLES USED IN COMPUTING THE RAOIATION
C
      COMMON AIRTEMC(25,6)
      COMMON CALDEF(25),CDMAX(25),COVDEN(25)
      COMMON DREADY(25)
      COMMON ENGBAL(25),ET,ETOAILY(25,12)
      COMMON FREEWAT(25)
      COMMON ISOTHRM(25,20)
      COMMON LASTUSD(25),LEVEL1,LEVEL2
      COMMON MMDD
      COMMON NDAYSNO(25),NDIVSBL,NSUB,NYEARS
      COMMON ONTREES(25)
      COMMON PEAKPPT(25,20),PEAKWEI(25,20),PHASE(25),POTENT(24),
      1 PREWEQV(25)
      COMMON RECHRG(25)
      COMMON SIMTEMI(25,3),SUBID(25,6),SLPASP(25,24)
      COMMON TCOEFF(25),THRSLO(25),TOPLLOT(11)
      COMMON VEGTYPE(25)
      COMMON WEIGHT(25),WSHEDID(16)
      COMMON YEARS(20),YYMMDD
      INTEGER DREADY
      INTEGER PHASE
      INTEGER SUBID
      INTEGER TOPLLOT
      INTEGER VEGTYPE
      INTEGER WSHEDID
      INTEGER YEARS,YYMMDD
      COMMON/MASTER/DATE(3),TMXMR,TMNMSTR,PPTMR,PPTONW,OBSHYDR,
      1 POTRAD,MSTREOF,IYR
      INTEGER DATE
      COMMON/RAD/FRACTON,ISUB
      COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RADIN,RADLWN,RADSWN,
      1 TEMPMAX,TEMPMIN,WATERIN
      DIMENSION BETWEEN(24),NOATE(24)
      DATA BETWEEN/13., 15., 13., 15., 14., 14., 15., 14., 15., 14.,
      2 21., 20., 15., 14., 15., 15., 14., 15., 14., 14., 14., 19.,
      2 19./
      DATA NOATE/ 110,123,207,220,307,321,404,419,503,518,601,622,712,
      1 727,810,825,909,923,1008,1022,1105,1119,1203,1222/
C-----PLACE THIS DATE WITH RESPECT TO THE TABLES
      GO 10 I = 1,24
      IF(NOATE(I) - MMDD) 10,80,20
10  CONTINUE
C-----A NORMAL TERMINATION OF THE DO LOOP MEANS THAT THIS DATE FALLS
C----- BETWEEN 12/23 AND 12/31, INCLUSIVE. USING THE ARRAY IN CIRCULAR
C----- FASHION, 1/10 (SUBSCRIPT 1) IS THE CONTROLLING DATE
      I = 1
      GO TO 30
C-----THIS DATE FALLS BETWEEN THE ONES AT LOCATIONS I AND I-1. IF I IS
C----- 1, USE 24 FOR I-1 SINCE THE ARRAY IS CIRCULAR
20  ISUB = 1 - I
      IF(I SUB) 30,30,40
30  ISUB = 24
C-----OBTAIN THE INTERPOLATION FRACTION. START BY OETERMINING IF
C----- THIS DATE FALLS IN THE SAME MONTH AS THAT AT LOCATION I OR I-1
40  IF(OATE(I) - INDATE(I SUB)/100) 60,50,60
C-----IT IS THE SAME AS I-1 AND IT IS LARGER, SO SUBTRACT THE I-1 DATE
C----- TO OBTAIN THE NUMBER OF OAYS TO BE USED FOR INTERPOLATING
50  OAYS = MMDD - NOATE(I SUB)
      GO TO 70
C-----IT IS THE SAME AS I, BUT IT IS SMALLER, SO SUBTRACT IT FROM THE I
C----- OATE. THEN SUBTRACT THE RESULT FROM THE DAYS BETWEEN I AND I-1
C----- TO OBTAIN THE NUMBER OF DAYS TO BE USED FOR INTERPOLATING
60  DAYS = NOATE(I) - MMDD
      DAYS = BETWEEN(I SUB) - OAYS
C-----COMPUTE THE INTERPOLATION FRACTION
70  FRACTON = DAYS/BETWEEN(I SUB)
      POTRAD = POTENT(I SUB) + (POTENT(I) - POTENT(I SUB)) * FRACTON

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      RETURN
C-----THIS DATE IS IN THE TABLE - NO INTERPOLATION IS NECESSARY
80  FRACTON = 0.0
      ISUB = 1
      POTRAD = POTENT(I)
      RETURN
      END

```

Subroutine RDMSTR

```

      SUBROUTINE RDMSTR
C-----READ A CARD FROM THE MASTER DECK
      COMMON AIRTEMC(25,6)
      COMMON CALDEF(25),CDMAX(25),COVDEN(25)
      COMMON DREADY(25)
      COMMON ENGBAL(25),ET,ETOAILY(25,12)
      COMMON FREEWAT(25)
      COMMON ISOTHRM(25,20)
      COMMON LASTUSD(25),LEVEL1,LEVEL2
      COMMON MMDD
      COMMON NDAYSNO(25),NDIVSBL,NSUB,NYEARS
      COMMON ONTREES(25)
      COMMON PEAKPPT(25,20),PEAKWEI(25,20),PHASE(25),POTENT(24),
      1 PREWEQV(25)
      COMMON RECHRG(25)
      COMMON SIMTEMI(25,3),SUBID(25,6),SLPASP(25,24)
      COMMON TCOEFF(25),THRSLO(25),TOPLLOT(11)
      COMMON VEGTYPE(25)
      COMMON WEIGHT(25),WSHEDID(16)
      COMMON YEARS(20),YYMMDD
      INTEGER DREADY
      INTEGER PHASE
      INTEGER SUBID
      INTEGER TOPLLOT
      INTEGER VEGTYPE
      INTEGER WSHEDID
      INTEGER YEARS,YYMMDD
      COMMON/MASTER/DATE(3),TMXMR,TMNMSTR,PPTMR,PPTONW,OBSHYDR,
      1 POTRAD,MSTREOF,IYR
      INTEGER DATE
      COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RADIN,RADLWN,RADSWN,
      1 TEMPMAX,TEMPMIN,WATERIN
      DIMENSION IN(8)
      EQUIVALENCE (DATE(1),IN(1))
      READ (5,910) IN
C-----THE FORMAT DECLARATORS ARE TYPED FOR THE EQUIVALENCED WORDS OF
C----- -IN- RATHER THAN FOR THE INTEGER ARRAY ITSELF
910  FORMAT(3I2,11X2F4,1,19X3F5,2)
      IF(EOF(5)) 20,20,10
20  MSTREOF = 1
      RETURN
20  MMDD = (DATE(1) * 100) + DATE(2)
      YYMMDD = (DATE(3) * 1000) + MMDD
C-----REDUCE -PPTONW- TO ITS VALUE BEFORE THE PRECIP FOR THIS DAY WAS
C----- ADDED IN
      PPTONW = PPTONW - PPTMR
C-----SINCE RADIATION MEASUREMENTS ARE NOT AVAILABLE, COMPUTE THE BASE
C----- STATION VALUE HERE
      CALL RADCOMP
      RETURN
      END

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Program SELECT

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      OVERLAY (OLAYS,1,0)
      PROGRAM SELECT
C-----SELECT THE METHOD OF OUTPUT AND READ THE WATERSHED PARAMETERS
      COMMON AIRTEMC(25,6)
      COMMON CALDEF(25),CDMAX(25),COVDEN(25)
      COMMON DREADY(25)
      COMMON ENGBAL(25),ET,ETOAILY(25,12)
      COMMON FREEWAT(25)
      COMMON ISOTHRM(25,20)
      COMMON LASTUSD(25),LEVEL1,LEVEL2
      COMMON MMDD
      COMMON NDAYSNO(25),NDIVSBL,NSUB,NYEARS
      COMMON ONTREES(25)
      COMMON PEAKPPT(25,20),PEAKWEI(25,20),PHASE(25),POTENT(24),
      1 PREWEQV(25)
      COMMON RECHRG(25)
      COMMON SIMTEMI(25,3),SUBID(25,6),SLPASP(25,24)
      COMMON TCOEFF(25),THRSLO(25),TOPLLOT(11)
      COMMON VEGTYPE(25)
      COMMON WEIGHT(25),WSHEDID(16)
      COMMON YEARS(20),YYMMDD
      INTEGER DREADY
      INTEGER PHASE
      INTEGER SUBID
      INTEGER TOPLLOT
      INTEGER VEGTYPE
      INTEGER WSHEDID
      INTEGER YEARS,YYMMDD
      COMMON/MASTER/DATE(3),TMXMR,TMNMSTR,PPTMR,PPTONW,OBSHYDR,
      1 POTRAD,MSTREOF,IYR
      INTEGER DATE
      COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RADIN,RADLWN,RADSWN,
      1 TEMPMAX,TEMPMIN,WATERIN
      DATA IERR/1/
C-----READ THE OUTPUT SELECTION AND CHECK FOR ERRORS
      READ (5,910) I,L1,L2,NOIVSBL
910  FORMAT(A6,1X11,1X11,1X12)
      IF(1.E0.6HSELECT) GO TO 20
10  WRITE (6,920) I,L1,L2,NOIVSBL

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920 FORMAT(1)THE SELECT CARO (FIRST CARD IN DECK) IS INCORRECT. EITHE
1R IT DOES NOT HAVE THE WORD -SELECT- IN COLUMNS 1-6, THE OUTPUT OP
2TION*/ IS NOT 2, 3 OR 4, OR THE -DATE DIVISIBLE BY- VALUE IS INVA
3L10*/5X=COLUMNS 1-6 = *A6/5X*OUTPUT OPTION (COL 8) = *I2/5X*ALTERNA
4TIVE (COL 10) = *I2/5X*DATE DIVISIBLE BY (COL 11-12) = *I3/*-JOB ABO
5RTEO*)
CALL EXIT
20 IF(I1.EQ.3.OR.L1.EQ.4) GO TO 50
IF(I1 - 2) 10,30,10
C-----OPTION 2 - CHECK THE DIVISIBILITY
30 IF(INDIVSBL) 10,10,40
40 IF(INDIVSBL - 3) 50,50,10
50 LEVEL1 = L1
LEVEL2 = L2 + 1
C-----READ THE PLOT CONTROL CARD AND CHECK FOR ERRORS
READ (5,930) I,TOPLLOT
930 FORMAT(A5,3X11(I1))
IF(I1.EQ.5HPLOTS) GO TO 60
WRITE (6,940)
940 FORMAT(1)THE SECOND CARD IN THE DATA DECK IS NOT THE PLOTS CARD -
1JOB ABORTED*)
CALL EXIT
C-----HYDROGRAPH
60 IF(TOPLLOT(1) - 3) 80,80,70
70 I = 10HYDROGRAPH
WRITE (6,950) IERR,I,TOPLLOT(1)
950 FORMAT(11,*THE *A10,* MAY NOT BE PRINTED ON BASE LINE*I2,* OF THE
1 PLOTS*)
IERR = 0
C-----WATER EQUIVALENT
80 IF(TOPLLOT(2) - 3) 100,100,90
90 I = 10WATER EQV
WRITE (6,950) IERR,I,TOPLLOT(2)
IERR = 0
C-----INPUT
100 IF(TOPLLOT(3) - 3) 120,120,110
110 I = 10INPUT
WRITE (6,950) IERR,I,TOPLLOT(3)
IERR = 0
C-----EVAPOTRANSPIRATION
120 IF(TOPLLOT(4) - 3) 140,140,130
130 I = 10EVAPOTR
WRITE (6,950) IERR,I,TOPLLOT(4)
IERR = 0
C-----STORAGE REQUIREMENTS (SINCE THIS IS A NEGATIVE QUANTITY, IT MAY
C----- NOT BE PRINTED AS PART OF LEVEL 1, BUT MAY BE PART OF A PSEUDO
C----- LEVEL, LEVEL 4)
140 IF(TOPLLOT(5).LT.-4.AND.TOPLLOT(5).NE.1) GO TO 150
I = 10HSTORAGE
WRITE (6,950) IERR,I,TOPLLOT(5)
IERR = 0
C-----RUNOFF
150 IF(TOPLLOT(6) - 3) 180,180,160
160 I = 10HURNOFF
WRITE (6,950) IERR,I,TOPLLOT(6)
170 CALL EXIT
180 IF(IERR) 170,170,190
C-----BE SURE THAT ALTERNATIVES PRINT ON THE SAME LEVEL AS THEIR
C----- COUNTERPARTS
190 00 210 I = 7,11
IF(TOPLLOT(1)) 210,210,200
200 TOPLLOT(1) = TOPLLOT(1-5)
210 CONTINUE
C-----READ THE WATERSHED DESCRIPTORS AND PARAMETERS
CALL RDPARAM
C-----WRITE THE FIRST LINES OF THE PLOT
REWIND 11
WRITE (11,960) WSHEDID,NSUB
960 FORMAT(1*54X*WATER BALANCE SIMULATION*/
1 1X6A10,41X*COMPOSITE OF*13,* SUBSTATIONS*//
2 *0*63X*LEGEND*/
3 1X2(12X*CHAR DEFINITION*15X* RANGE*12X)/
4 14X*A ALTERNATIVE RESULT FOR NEAREST CHARACTER *
5 10X*R RUNOFF-SIMULATED GEN 0 TO 2.0 INCHES */
6 14X*E EVAPOTRANSPIRATION 0 TO 2 INCH *
7 10X*S STORAGE REQUIREMENTS -5.3 TO 0 INCHES */
8 14X*H HYDROGRAPH-OBS GENRO 0 TO .5 AREA INCHES */
9 10X*W WATER EQUIV OF PACK 0 TO 30.0 INCHES */
A 14X*I INPUT - MELT OR RAIN 0 TO 2.0 INCHES */(*0*)
C-----RETURN TO THE MAIN OVERLAY FOR THE LOADING OF THE NEXT OVERLAY
END

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Subroutine RDPARAM

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SUBROUTINE RDPARAM
C-----READ THE WATERSHED PARAMETERS AND DESCRIPTORS
COMMON AIRTEMC(25,6)
COMMON CALDEF(25),CDMAX(25),COVDEN(25)
COMMON DREADY(25)
COMMON ENGBAL(25),ET,ETDAILY(25,12)
COMMON FREEWAT(25)
COMMON ISOTHRM(25,20)
COMMON LASTUSD(25),LEVEL1,LEVEL2
COMMON MMDO
COMMON NDAYSND(25),NDIVSBL,NSUB,NYEARS
COMMON ONTREES(25)
COMMON PEAKPPT(25,20),PEAKWE(25,20),PHASE(25),POTENT(24),
PREWEQV(25)
COMMON RECHRG(25)
COMMON SIMTEMI(25,3),SUBID(25,6),SLPASP(25,24)
COMMON TCDEFF(25),THRSLO(25),TOPLLOT(11)
COMMON VEGTYPE(25)
COMMON WEIGHT(25),WSHEDIO(6)
COMMON YEARS(20),YMMMOD

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INTEGER DREADY
INTEGER PHASE
INTEGER SUBIO
INTEGER TOPLLOT
INTEGER VEGTYPE
INTEGER WSHEDIO
INTEGER YEARS,YMMMOD
COMMON/CHPSIT/COMPS11(6),YRTOT(15)
COMMON/MASTER/DATE(3),THXSTR,THNSTR,PPTMSTR,PPTONOW,OBSHYDR,
1 POTRAQ,MSTREOF,IYR
INTEGER DATE
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RADIN,RAOLWN,RADSWN,
1 TEMPMAX,TEMPMIN,WATERIN
INTEGER PEAKOAT
DATA IERR,N/2*1/
C-----READ THE WATERSHED TITLE AND NUMBER OF SUBSTATIONS
READ (5,900) WSHEDID,NSUB,NYEARS
900 FORMAT(6A10,14X2I3)
IF(NSUB.GE.1.AND.NSUB.LE.25) GO TO 10
WRITE (6,901) IERR,NSUB
901 FORMAT(11,13,* SUBSTATIONS MAY NOT BE RUN. COLUMNS 76-77 OF THE W
1ATERSHED ID CARD MUST BE 1 TO 25, INCLUSIVE (OR THE PROGRAM MAY BE
2 REVISED*)
IERR = 0
10 IF(NYEARS.GE.1.AND.NYEARS.LE.20) GO TO 20
WRITE (6,902) IERR,NYEARS
902 FORMAT(11,13,* YEARS MAY NOT BE RUN. COLUMNS 79-80 OF THE WATERSH
1ED TO CARD MUST BE 1 TO 20, INCLUSIVE (OR THE PROGRAM MAY BE REVIS
2ED*)
IERR = 0
C-----READ THE POTENTIAL RADIATION CARDS (2 CARDS)
20 READ (5,910) NAME,POTENT
910 FORMAT(A10,10X12F5.0/20X12F5.0)
IF(NAME.EQ.10HPOTENT) GO TO 30
WRITE (6,911) IERR
911 FORMAT(11,*THE POTENTIAL RADIATION CARDS DO NOT FOLLOW THE WATERSH
1ED TO CARD*)
IERR = 0
C-----SEE IF THERE ARE SUBSTATIONS TO BE READ
30 IF(NSUB) 210,210,60
60 NSETS = NSUB
C-----READ A SET OF SUBSTATION DESCRIPTORS. START WITH THE ID AND
C----- CONSTANT PARAMETERS
70 READ (5,930) (SUBIDIN(I),I=1,6),TCOFFIN,COVDENIN,CDMAXIN,
1 WEIGHTIN,THRSLOIN,VEGTYPIN)
930 FORMAT(6A10,4F4.2,F2.0,1X11)
IF(CDMAXIN).GE.COVDENIN) GO TO 80
WRITE (6,931) IERR,(SUBIDIN(I),I=1,6),COVDENIN,CDMAXIN)
931 FORMAT(11,*ON THE SUBSTATION ID CARD ENTITLED *A10/* THE COVER DE
1NSITY SPECIFIED IN COLUMNS 65-68 (*F5.2,*) IS GREATER THAN THE MAX
2IMUM COVER DENSITY IN COLUMNS 69-72 (*F5.2,*)*)
IERR = 0
80 IF(WEIGHTIN).GT.0.0.AND.WEIGHTIN.LE.1.0) GO TO 90
WRITE (6,932) IERR,WEIGHTIN,(SUBIDIN(I),I=1,6)
932 FORMAT(11,*INVALID WEIGHT (*F5.2,*) IN COL 73-76 OF SUBSTATION ID
1CARD ENTITLED *A10/* WEIGHT MUST BE BETWEEN 0.001 AND 1.0, INCLUS
2IVE*)
IERR = 0
90 IF(VEGTYPIN).EQ.1.OR.VEGTYPIN.EQ.2) GO TO 100
WRITE (6,933) IERR,VEGTYPIN,(SUBIDIN(I),I=1,6)
933 FORMAT(11,*INVALID VEG TYPE *I1,*) IN COLUMN 80 OF SUBSTATION ID
1CARD ENTITLED *A10/* VEGETATION TYPE = 1 (LOGDGEPOLE PINE), = 2 (S
2PRUCE FIR*)
IERR = 0
C-----READ THE INITIAL CONDITIONS CARD
100 READ (5,940) NAME,SIMTEMI(1,2),PREWEQVIN,RECHRGIN,SIMTEMI(1,1),
1 DREADYIN)
940 FORMAT(A10,10X4F5.2,15)
IF(NAME.EQ.10HINITIAL CO) GO TO 110
WRITE (6,941) IERR,(SUBIDIN(I),I=1,6)
941 FORMAT(11,* THE INITIAL CONDITIONS CARD DOES NOT FOLLOW THE SUBSTA
1TION ID CARD ENTITLED*/1X6A10)
IERR = 0
GO TO 130
C-----CONVERT THE PACK TEMPERATURE TO CALORIE DEFICIT (AS A POSITIVE
C----- QUANTITY), INCLUDE THE WEIGHTED RECHARGE REQUIREMENT FOR USE IN
C----- THE -CHANGE IN STORAGE- COMPUTATION, AND DEFINE THE GROUND
C----- TEMPERATURE FOR THE SIMULATION MODEL
110 CALDEFIN = - SIMTEMI(1,2) * PREWEQVIN * 1.27
YRTOT(4) = YRTOT(4) + (RECHRGIN * WEIGHTIN)
SIMTEMI(1,3) = - 1.5
C-----READ THE DAILY ET VALUES
130 READ (5,950) NAME,(ETDAILYIN(I),I=1,12)
950 FORMAT(A10,10X12F5.4)
IF(NAME.EQ.10HDAILY ET ) GO TO 140
WRITE (6,951) IERR,(SUBIDIN(I),I=1,6)
951 FORMAT(11,* THE DAILY ET VALUES CARD DOES NOT FOLLOW THE INITIAL C
1ONDITIONS CARD IN THE CARDS FOLLOWING THE SUBSTATION ID CARD ENTIT
2LED*/1X6A10)
IERR = 0
C-----READ THE AIR TEMPERATURE COEFFICIENTS
140 READ (5,960) NAME,(AIRTEMCIN(I),I=1,6)
960 FORMAT(A10,10X6F5.3)
IF(NAME.EQ.10HAIR TEMP C) GO TO 150
WRITE (6,961) IERR,(SUBIDIN(I),I=1,6)
961 FORMAT(11,*THE AIR TEMPERATURE COEFFICIENTS CARD DOES NOT FOLLO W
1HE DAILY ET CARD IN THE CARDS FOLLOWING THE SUBSTATION ID CARD ENT
2ITLED*/1X6A10)
IERR = 0
C-----READ THE SLOPE/ASPECT ADJUSTMENT FACTORS
150 READ (5,970) NAME,(SLPASPIN(I),I=1,24)
970 FORMAT(A6,2X24F3.2)
IF(NAME.EQ.6HSLP/AS) GO TO 160
WRITE (6,971) IERR,(SUBIDIN(I),I=1,6)

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971 FORMAT(11,*THE SLOPE/ASPECT CORRECTION FACTORS CARO DOES NOT FOLLO
1W THE AIR TEMPERATURE COEFFICIENTS CARO FOLLOWING THE SUBSTATION I
20 CARO*/IX6A10)
IERR = 0
C-----READ THE PEAK WATER EQUIVALENT, ITS DATE AND THE DATE BY WHICH THE
C-----PACK MUST BE ISOTHERMAL FOR EACH YEAR
160 DO 190 I = 1, NYEARS
READ (5,980) PEAKWE(N,I),TEMP,PEAKDAT,ITEMP
980 FORMAT(20X2F5.2,1X16,1X16)
C-----FOR RAPID AND MORE ACCURATE BINARY COMPARES IN SUBROUTINE GENOATA,
C-----LOWER THE PEAK PRECIP SLIGHTLY
PEAKPPT(N,I) = TEMP - 0.001
IFIN - 1) 170,170,180
170 YEARS(I) = MOO(PEAKDAT,100)
GO TO 190
180 IF(YEARS(I).EQ.MOO(PEAKDAT,100)) GO TO 190
K = MOO(PEAKDAT,100)
WRITE (6,981) IERR,(SUBID(N,J),J=1,6),YEARS(I),K,(YEARS(J),J=1,
1 NYEARS)
981 FORMAT(11,*THE PEAK W.E. CAROS FOLLOWING THE SUBSTATION IO CARO EN
1TITLED *6A10/* DO NOT CORRESPOND TO THE YEARS AND/OR ORDER OF THE
2FIRST SET READ. WHEN*13,* WAS EXPECTED,*13,* WAS READ.*/* THE FIR
3ST SET ISO*2014)
IERR = 0
C-----CONVERT THE ISOTHERMAL DATE TO YMMOO FORMAT FOR RAPID COMPARES
190 ISOTHRM(N,I) = (10000 * ITEMP) - (999999 * (ITEMP/100))
C-----GO ON TO THE NEXT SET
N = N + IERR
NSETS = NSETS + 1
IF(NSETS) 200,200,70
200 IF(IERR) 210,210,220
210 WRITE (6,990)
990 FORMAT(*0*/OJOB ABORTED FOR ABOVE REASON(S) WHILE OPERATING IN SU
BRROUTINE ROPARAM*)
CALL EXIT
C-----INITIALIZE THE VARIABLES THAT HAVE NOT BEEN DEFINED ABOVE
220 DO 230 N = 1,25
ENGBAL(N) = -1.0
FREEWAT(N) = 0.0
LASTUSO(N) = 0
NDAYSNO(N) = 0
ONTREES(N) = 0.0
230 PHASE(N) = 0
C-----SUM THE WEIGHTS TO CERTIFY THAT A COMPLETE SET OF PARAMETERS IS
C-----INCLUDED
SUM = 0.0
DO 240 N = 1, NSUB
240 SUM = SUM + WEIGHT(N)
IF(SUM.GT.0.97.AND.SUM.LT.1.03) RETURN
WRITE (6,991) IERR,SUM
991 FORMAT(11,*THE TOTAL OF THE WEIGHTING FACTORS (*F6.3,*) IS OUTSIDE
1 THE TOLERABLE TOTALS, 0.97 TO 1.03*)
GO TO 210
END

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Program INTSUM

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OVERLAY (OLAYS,2,0)
PROGRAM INTSUM
C-----INTERVAL SUMS OF VALUES CONCERNED WITH WATER - LOAD APPROPRIATE
C-----OPERATING PROGRAM TO WORK WITH THE SUBROUTINES IN THIS OVERLAY
COMMON AIRTEM(25,6)
COMMON CALDEF(25),COMAX(25),COVOEN(25)
COMMON OREADY(25)
COMMON ENGBAL(25),ET,ETDAILY(25,12)
COMMON FREEWAT(25)
COMMON ISOTHRM(25,20)
COMMON LASTUSO(25),LEVEL1,LEVEL2
COMMON MM00
COMMON NOAYSNO(25),NOIVSBL,NSUB,NYEARS
COMMON ONTREES(25)
COMMON PEAKPPT(25,20),PEAKWE(25,20),PHASE(25),POTENT(24),
1 PREWEQV(25)
COMMON RECHRG(25)
COMMON SIMTEMI(25,3),SUBID(25,6),SLPASP(25,24)
COMMON TCoeff(25),THRSLO(25),TOPLOT(11)
COMMON VEGTYPE(25)
COMMON WEIGHT(25),WSHEDIO(6)
COMMON YEARS(20),YMM00
INTEGER OREADY
INTEGER PHASE
INTEGER SUBID
INTEGER TOPLOT
INTEGER VEGTYPE
INTEGER WSHEDIO
INTEGER YEARS,YMM00
COMMON/MASTER/DATE(3),TMXSTR,TMNSTR,PPTMSTR,PPTONOW,OBSHYOR,
1 POTRAO,MSTREOF,IYR
INTEGER DATE
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RAOIN,RADLWN,RAOSWN,
1 TEMPMAX,TEMPMIN,WATERIN
CALL OVERLAY (5HOLAYS,2,LEVEL2)
C-----RETURN TO THE MAIN OVERLAY TO TERMINATE NORMALLY
END

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Subroutine NORM2

```

SUBROUTINE NORM2 (N)
C-----THE VERSION OF THE NORMAL SIMULATION SUMS THOSE VALUES CONCERNED
C-----WITH WATER FOR OUTPUT ON DATES DIVISIBLE BY THE SPECIFIED NUMBER
COMMON AIRTEM(25,6)
COMMON CALDEF(25),COMAX(25),COVOEN(25)
COMMON OREADY(25)
COMMON ENGBAL(25),ET,ETDAILY(25,12)

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COMMON FREEWAT(25)
COMMON ISOTHRM(25,20)
COMMON LASTUSO(25),LEVEL1,LEVEL2
COMMON MM00
COMMON NOAYSNO(25),NOIVSBL,NSUB,NYEARS
COMMON ONTREES(25)
COMMON PEAKPPT(25,20),PEAKWE(25,20),PHASE(25),POTENT(24),
1 PREWEQV(25)
COMMON RECHRG(25)
COMMON SIMTEMI(25,3),SUBID(25,6),SLPASP(25,24)
COMMON TCoeff(25),THRSLO(25),TOPLOT(11)
COMMON VEGTYPE(25)
COMMON WEIGHT(25),WSHEDIO(6)
COMMON YEARS(20),YMM00
INTEGER OREADY
INTEGER PHASE
INTEGER SUBID
INTEGER TOPLOT
INTEGER VEGTYPE
INTEGER WSHEDIO
INTEGER YEARS,YMM00
COMMON/CMPSITO/CMPS(16),YRTOT(5)
COMMON/MASTER/DATE(3),TMXSTR,TMNSTR,PPTMSTR,PPTONOW,OBSHYOR,
1 POTRAO,MSTREOF,IYR
INTEGER DATE
COMMON/PLOTS/PLOT(6)
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RAOIN,RADLWN,RAOSWN,
1 TEMPMAX,TEMPMIN,WATERIN
C-----MAKE THE PASS THROUGH THE WATER BALANCE ROUTINES
CALL WATBAL (CALDEF(N),COMAX(N),COVOEN(N),OREADY(N),ENGBAL(N),
1 FREEWAT(N),LASTUSO(N),NOAYSNO(N),ONTREES(N),PHASE(N),PREWEQV(N),
2 RECHRG(N),SIMTEMI(N,1),SIMTEMI(N,2),SIMTEMI(N,3),TCoeff(N),
3 THRSLO(N),VEGTYPE(N))
C-----CHECK THE MANDATORY ISOTHERMAL DATE
IF(YMM00 - ISOTHRM(N,IYR)) 20,10,20
C-----TURN OFF THE DIFFUSION MODEL, SET THE PACK TO O C AND ADJUST THE
C-----ENERGY BALANCE ACCORDINGLY
10 OREADY(N) = -1
ENGBAL(N) = ENGBAL(N) + CALOEF(N)
RADLWN = RADLWN + CALOEF(N)
CALDEF(N) = 0.0
C-----WEIGHT AND STORE THIS DATA
20 WT = WEIGHT(N)
CMPS(1) = CMPS(1) + (PREWEQV(N) * WT)
CMPS(2) = CMPS(2) + (RECHRG(N) * WT)
CMPS(13) = CMPS(13) + (PRECIP * WT)
CMPS(14) = CMPS(14) + (WATERIN * WT)
CMPS(15) = CMPS(15) + (EVAPOTR * WT)
CMPS(16) = CMPS(16) + (GENRO * WT)
CALL ETCODE (ETFROM,CMPS(6))
RETURN
END

```

Subroutine WRITE2

```

SUBROUTINE WRITE2 (K,CMPS)
C-----THIS VERSION OF THE OUTPUT ROUTINE PRINTS INTERVAL AND YEAR-TO-
C-----DATE SUMS OF ALL VALUES CONCERNED WITH WATER
COMMON AIRTEM(25,6)
COMMON CALOEF(25),COMAX(25),COVOEN(25)
COMMON OREADY(25)
COMMON ENGBAL(25),ET,ETDAILY(25,12)
COMMON FREEWAT(25)
COMMON ISOTHRM(25,20)
COMMON LASTUSO(25),LEVEL1,LEVEL2
COMMON MM00
COMMON NOAYSNO(25),NOIVSBL,NSUB,NYEARS
COMMON ONTREES(25)
COMMON PEAKPPT(25,20),PEAKWE(25,20),PHASE(25),POTENT(24),
1 PREWEQV(25)
COMMON RECHRG(25)
COMMON SIMTEMI(25,3),SUBID(25,6),SLPASP(25,24)
COMMON TCoeff(25),THRSLO(25),TOPLOT(11)
COMMON VEGTYPE(25)
COMMON WEIGHT(25),WSHEDIO(6)
COMMON YEARS(20),YMM00
INTEGER OREADY
INTEGER PHASE
INTEGER SUBID
INTEGER TOPLOT
INTEGER VEGTYPE
INTEGER WSHEDIO
INTEGER YEARS,YMM00
COMMON/FORDATA/ FOOTNOT(26),MAXLINE
INTEGER FOOTNOT
COMMON/MASTER/DATE(3),TMXSTR,TMNSTR,PPTMSTR,PPTONOW,OBSHYOR,
1 POTRAO,MSTREOF,IYR
INTEGER DATE
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RAOIN,RADLWN,RAOSWN,
1 TEMPMAX,TEMPMIN,WATERIN
DIMENSION CMPS(12),FROM(7)
DATA LINES/-1/
DATA FROM/3HC ,3H S ,3HCS ,3H E,3HC E,3H SE,3HCS/
CMPS(6) = FROM(CMPS(6))
C-----DETERMINE HOW TO WRITE THE LINE
IF(K.EQ.1HS) GO TO 10
WRITE (6,910) K,CMPS
910 FORMAT(1XA10,2F10.2,6X2F8.2,F8.4,1XA3,F9.2,7X2F8.2,F10.4,1X2F10.2)
LINES = LINES + 1
RETURN
C-----CHECK THE LINE COUNTER
10 IF(LINES) 20,20,30
20 WRITE (6,920) FOOTNOT,WSHEDIO,NSUB
920 FORMAT(*0*13A10/1X13A10/*1*54X*WATER BALANCE SIMULATION*/

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1 1X6A10,41X*COMPOSITE OF*I3,* SUBSTATIONS*/
2 *O*16X*C U R R E N T*I2X*I N T E R V A L   T O T A L S*13X
3 *-- -- -- Y E A R   T O   O A T E   -   -   -*/
4 14X*SNOWPACK RECHARGE*23X*EVAPOTRANS GENERATEO*38X
5 *GEN CHANGE IN*/
6 16X*W. E. REQ PRECIP INPUT FROM RUNOFF
7 *PRECIP INPUT EVAPOTRANS RUNOFF RECHRG RQ*/
8
9 LINES = MAXLINE
10 WRITE (6,930) OATE,COMPS
930 FORMAT(* *313,1X2F10.2,6X2F8.2,F8.4,1XA3,F9.2,7X2F8.2,F10.4,1X
1 2F10.2)
11 LINES = LINES - 1
12 RETURN
13 C-----DOUBLE SPACE BETWEEN YEARS
14 ENTRY WRITOT
15 WRITE (6,910)
16 LINES = LINES - 1
17 RETURN
18 ENO

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Program INTSUMO

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OVERLAY (OLAYS,2,1)
PROGRAM INTSUMO
C-----OPERATING PROGRAM FOR PRINTING INTERVAL SUMS FOR THE NORMAL
C-----SIMULATION WITHOUT ANY ALTERNATIVES
COMMON AIRTEMC(25,6)
COMMON CALDEF(25),COMAX(25),COVDEN(25)
COMMON OREADY(25)
COMMON ENGBAL(25),ET,ETOAILY(25,12)
COMMON FREEWAT(25)
COMMON ISOTHRM(25,20)
COMMON LASTUSO(25),LEVEL1,LEVEL2
COMMON MMDO
COMMON NOAYSNO(25),NOIVSBL,NSUB,NYEARS
COMMON ONTREES(25)
COMMON PEAKPPT(25,20),PEAKWE(25,20),PHASE(25),POTENT(24),
1 PREMEQV(25)
COMMON RECHRG(25)
COMMON SIMTEM1(25,3),SUBIO(25,6),SLPASP(25,24)
COMMON TCDEFF(25),THRSBLD(25),TOPLOT(11)
COMMON VEGTYPE(25)
COMMON WEIGHT(25),WSHEDIO(6)
COMMON YEARS(20),YYMMDO
INTEGER OREADY
INTEGER PHASE
INTEGER SUBIO
INTEGER TOPLOT
INTEGER VEGTYPE
INTEGER WSHEDIO
INTEGER YEARS,YYMMDO
COMMON/CMPSIT/COMPS(16),YRTOT(5)
COMMON/FORDATA/ FOOTNOT(26),MAXLINE
INTEGER FOOTNOT
COMMON/MASTER/OATE(3),TMXMSTR,TMNMSTR,PPTMSTR,PPTONOW,OBSHYOR,
1 POTRAD,MSTREOF,IYR
INTEGER OATE
COMMON/PLOTS/PLOT(11)
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RADIN,RAOLWN,RADSWN,
1 TEMPMAX,TEMPMIN,WATERIN
INTEGER FOOTNTE(26)
DATA FOOTNTE/260HNORMAL SIMULATION ONLY
1
2
3
4
C-----DEFINE THE FOOTNOTE
DO 1 N = 1,26
1 FOOTNTE(N) = FOOTNTE(N)
C-----MAXLINE = 52 - NUMBER OF ALTERATIONS
MAXLINE = 52
C-----WRITE THE FOOTNOTE ON THE PLOT
WRITE (11,900) FOOTNOT
900 FORMAT(/O*13A10/1X13A10/)
C-----READ A MASTER CARD
10 CALL ROMSTR
IF(MSTREOF) 20,20,170
C-----GENERATE THE DATA AND PERFORM THE SIMULATION FOR EACH SUBSTATION
20 DO 30 N = 1,NSUB
CALL GENDATA (N)
CALL NORM2 (N)
30 CONTINUE
C-----STORE THE INFORMATION FOR THE PLOTS
PLOT(1) = OBSHYOR
PLOT(2) = COMPS(1)
PLOT(3) = COMPS(14)
PLOT(4) = COMPS(15)
PLOT(5) = COMPS(12)
PLOT(6) = COMPS(16)
C-----ADD THESE VALUES INTO THE INTERVAL LOCATIONS
COMPS(3) = COMPS(3) + COMPS(13)
COMPS(4) = COMPS(4) + COMPS(14)
COMPS(5) = COMPS(5) + COMPS(15)
COMPS(7) = COMPS(7) + COMPS(16)
C-----ZERO THE DAILY COMPOSITE LOCATIONS
DO 40 N = 1,16
40 COMPS(N) = 0.0
C-----SEE IF THIS DAY IS TO BE PRINTED
IF(MDO (OATE(2),NOIVSBL)) 70,50,70
C-----ADD THESE TOTALS INTO THE YEAR-TO-DATE LOCATIONS, GET THE CHANGE
IN THE RECHARGE REQUIREMENTS AND PRINT THE LINE
50 COMPS(8) = COMPS(8) + COMPS(3)
COMPS(9) = COMPS(9) + COMPS(4)
COMPS(10) = COMPS(10) + COMPS(5)

```

```

COMPS(11) = COMPS(11) + COMPS(7)
COMPS(12) = COMPS(2) - YRTOT(4)
CALL WRITE2 (1H$,COMPS)
C-----ZERO THE INTERVAL ACCUMULATING LOCATIONS
DO 60 N = 3,7
60 COMPS(N) = 0.0
C-----PERFORM THE PLOTS BETWEEN APRIL 1 AND SEPTEMBER 30
70 IF(MMOO - 401) 160,140,80
80 IF(930 - MMDO) 160,90,150
C-----ON 9/30, STORE THE CURRENT RECHARGE REQUIREMENT, ZERO THE YEARLY
C-----ACCUMULATING LOCATIONS, AND RESET THE DIFFUSION MODEL SWITCHES
90 YRTOT(4) = COMPS(2)
DO 100 N = 8,11
100 COMPS(N) = 0.0
DO 110 N = 1,NSUB
110 OREADY(N) = 0
C-----CHECK THE YEARS TO BE SURE ALL DECKS STILL CORRESPOND TO THE
C-----PARAMETER DECK
IF(OATE(3) - YEARS(IYR)) 120,130,120
120 WRITE (6,910) OATE(3),IYR,IYR,YEARS(IYR)
910 FORMAT(*1THE OATA DECKS ARE OUT OF PHASE WITH THE WATERSHED PARAME
1TER DECK. THE WATER YEAR JUST ENDING (19*I2,*) IS DECK NUMBER*I3,
2 *,*/* BUT SPECIFIED CONDITIONS CARD NUMBER*I3,* FOR EACH SUBST
3ION IS FOR 19*I2)
CALL EXIT
130 IYR = IYR + 1
C-----DOUBLE SPACE BETWEEN YEARS
CALL WRITOT (1H$,YRTOT)
GO TO 150
C-----ON 4/1, WRITE THE ORINATE LINE
140 WRITE (11,920)
920 FORMAT(9X124(1H.))
150 CALL PLOTTER
C-----ZERO THE CURRENT LOCATIONS
160 COMPS(1) = 0.0
COMPS(2) = 0.0
GO TO 10
C-----ALL CARDS HAVE BEEN REAO. IF A LINE WAS NOT PRINTED ON THE LAST
C-----DAY PROCESSED, DO IT NOW
170 IF(MDO (MMDO,NOIVSBL)) 180,190,180
180 COMPS(8) = COMPS(8) + COMPS(3)
COMPS(9) = COMPS(9) + COMPS(4)
COMPS(10) = COMPS(10) + COMPS(5)
COMPS(11) = COMPS(11) + COMPS(7)
COMPS(12) = COMPS(2) - YRTOT(4)
CALL WRITE2 (1H$,COMPS)
C-----WRITE THE FOOTNOTE ON THE LAST PAGE
190 WRITE (6,930) FOOTNOT
930 FORMAT(/O*13A10/1X13A10)
C-----RETURN TO THE MAIN OVERLAY FOR NORMAL TERMINATION
ENO

```

Program DAILY

```

OVERLAY (OLAYS,3,0)
PROGRAM DAILY
C-----COMPOSITE DAILY OUTPUT - LOAD APPROPRIATE OPERATING PROGRAM TO
C-----WORK WITH THE SUBROUTINES IN THIS OVERLAY
COMMON AIRTEMC(25,6)
COMMON CALDEF(25),COMAX(25),COVDEN(25)
COMMON OREADY(25)
COMMON ENGBAL(25),ET,ETOAILY(25,12)
COMMON FREEWAT(25)
COMMON ISOTHRM(25,20)
COMMON LASTUSO(25),LEVEL1,LEVEL2
COMMON MMDO
COMMON NOAYSNO(25),NOIVSBL,NSUB,NYEARS
COMMON ONTREES(25)
COMMON PEAKPPT(25,20),PEAKWE(25,20),PHASE(25),POTENT(24),
1 PREMEQV(25)
COMMON RECHRG(25)
COMMON SIMTEM1(25,3),SUBIO(25,6),SLPASP(25,24)
COMMON TCDEFF(25),THRSBLD(25),TOPLOT(11)
COMMON VEGTYPE(25)
COMMON WEIGHT(25),WSHEDIO(6)
COMMON YEARS(20),YYMMDO
INTEGER OREADY
INTEGER PHASE
INTEGER SUBIO
INTEGER TOPLOT
INTEGER VEGTYPE
INTEGER WSHEDIO
INTEGER YEARS,YYMMDO
COMMON/MASTER/OATE(3),TMXMSTR,TMNMSTR,PPTMSTR,PPTONOW,OBSHYOR,
1 POTRAD,MSTREOF,IYR
INTEGER OATE
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RADIN,RAOLWN,RADSWN,
1 TEMPMAX,TEMPMIN,WATERIN
CALL OVERLAY (5HOLAYS,3,LEVEL2)
C-----RETURN TO THE MAIN OVERLAY TO TERMINATE NORMALLY
ENO

```

Subroutine NORM3

```

SUBROUTINE NORM3 (N)
C-----THIS VERSION OF THE NORMAL SIMULATION MAINTAINS ALL INFORMATION
C-----NECESSARY OF THE PRINTING OF ONE LINE PER DAY FOR THE WATERSHED
C-----COMPOSITE
COMMON AIRTEMC(25,6)
COMMON CALDEF(25),COMAX(25),COVDEN(25)
COMMON OREADY(25)
COMMON ENGBAL(25),ET,ETOAILY(25,12)
COMMON FREEWAT(25)

```



```

COMMON ISOHRM(25,20)
COMMON LASTUSO(25),LEVEL1,LEVEL2
COMMON MM00
COMMON NOAYSNO(25),NOIVSBL,NSUB,NYEARS
COMMON ONTREES(25)
COMMON PEAKPPT(25,20),PEAKWE(25,20),PHASE(25),POTENT(24),
1 PREWEQV(25)
COMMON RECHRG(25)
COMMON SIMTEMI(25,3),SUBIO(25,6),SLPASP(25,24)
COMMON TC0EFF(25),THRSHLO(25),TOPLOT(11)
COMMON VEGTYPE(25)
COMMON WEIGHT(25),WSHEOIO(6)
COMMON YEARS(20),YYMM00
INTEGER OREADY
INTEGER PHASE
INTEGER SUBIO
INTEGER TOPLOT
INTEGER VEGTYPE
INTEGER WSHEOIO
INTEGER YEARS,YYMM00
COMMON/CMPSITO/COMPS(16),YRTOT(5)
COMMON/MASTER/DATE1(3),TMXMSTR,TMNMSTR,PPTMSTR,PPTONOW,OBSHYOR,
1 POTRAO,MSTREOF,IYR
INTEGER DATE
COMMON/PLOTS/PL0T(6)
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RADIN,RAOLWN,RAOSWN,
1 TEMPMAX,TEMPMIN,WATERIN
C-----MAKE THE PASS THROUGH THE WATER BALANCE ROUTINES
CALL WATBAL(CALOE(N),COMAX(N),COVOEN(N),OREADY(N),ENGBAL(N),
1 FREEWAT(N),LASTUSO(N),NOAYSNO(N),ONTREES(N),PHASE(N),PREWEQV(N),
2 RECHRG(N),SIMTEMI(N,1),SIMTEMI(N,2),SIMTEMI(N,3),TC0EFF(N),
3 THRSHLO(N),VEGTYPE(N))
C-----CHECK THE MANDATORY ISOTHERMAL DATE
IFYMM00 = ISOHRM(N,IYR) 20,10,20
C-----TURN OFF THE DIFFUSION MODEL, SET THE PACK TO 0 C AND ADJUST THE
C-----ENERGY BALANCE ACCORDINGLY
10 OREADY(N) = -1
ENGBAL(N) = ENGBAL(N) + CALOE(N)
RAOLWN = RAOLWN + CALOE(N)
CALOE(N) = 0.0
C-----WEIGHT AND STORE THIS DATA
20 WT = WEIGHT(N)
COMPS(1) = COMPS(1) + (TEMPMAX * WT)
COMPS(2) = COMPS(2) + (TEMPMIN * WT)
COMPS(3) = COMPS(3) + (PRECIP * WT)
IF(PREWEQV(N)) 40,40,30
30 COMPS(4) = COMPS(4) + (ONTREES(N) * WT)
COMPS(5) = COMPS(5) + (RAOSWN * WT)
COMPS(6) = COMPS(6) + (RAOLWN * WT)
COMPS(7) = COMPS(7) + (ENGBAL(N) * WT)
COMPS(8) = COMPS(8) + (CALOE(N) * WT)
COMPS(9) = COMPS(9) + (PREWEQV(N) * WT)
40 COMPS(10) = COMPS(10) + (WATERIN * WT)
COMPS(11) = COMPS(11) + (EVAPOTR * WT)
COMPS(13) = COMPS(13) + (RECHRG(N) * WT)
COMPS(14) = COMPS(14) + (GENRO * WT)
CALL ETCD0E (ETFROM,COMPS(12))
RETURN
END

```

Function ROUNDE

```

FUNCTION ROUNDE(SIGN)
C-----DETERMINE THE SIGN FOR ROUNDING
IF(SIGN) 10,20,20
10 ROUNDE = -0.5
RETURN
20 ROUNDE = 0.5
RETURN
END

```

Subroutine WRITE3

```

SUBROUTINE WRITE3 IK,COMPS)
C-----THIS VERSION OF THE OUTPUT ROUTINE PRINTS ONE COMPOSITE LINE PER
C-----DAY
COMMON AIRTEMC(25,6)
COMMON CALOE(25),COMAX(25),COVOEN(25)
COMMON OREADY(25)
COMMON ENGBAL(25),ET,ETOAILY(25,12)
COMMON FREEWAT(25)
COMMON ISOHRM(25,20)
COMMON LASTUSO(25),LEVEL1,LEVEL2
COMMON MM00
COMMON NOAYSNO(25),NOIVSBL,NSUB,NYEARS
COMMON ONTREES(25)
COMMON PEAKPPT(25,20),PEAKWE(25,20),PHASE(25),POTENT(24),
1 PREWEQV(25)
COMMON RECHRG(25)
COMMON SIMTEMI(25,3),SUBIO(25,6),SLPASP(25,24)
COMMON TC0EFF(25),THRSHLO(25),TOPLOT(11)
COMMON VEGTYPE(25)
COMMON WEIGHT(25),WSHEOIO(6)
COMMON YEARS(20),YYMM00
INTEGER OREADY
INTEGER PHASE
INTEGER SUBIO
INTEGER TOPLOT
INTEGER VEGTYPE
INTEGER WSHEOIO
INTEGER YEARS,YYMM00
COMMON/FORDATA/ FOOTNOT(26),MAXLINE
INTEGER FOOTNOT
COMMON/MASTER/DATE1(3),TMXMSTR,TMNMSTR,PPTMSTR,PPTONOW,OBSHYOR,

```

```

1 POTRAO,MSTREOF,IYR
INTEGER DATE
COMMON/WATRBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RADIN,RAOLWN,RAOSWN,
1 TEMPMAX,TEMPMIN,WATERIN
COMMON/CMPSITO/COMPS(16),YRTOT(5)
COMMON/MASTER/DATE1(3),TMXMSTR,TMNMSTR,PPTMSTR,PPTONOW,OBSHYOR,
EQUIVALENCE (OUT(1),OUT(11))
DATA LINES/-1/
DATA FROM/3HC +3H S ,3HCS +3H E,3HC E,3H SE,3HCSE/
J = 0
IF(COMPS(14).LE.0.0) J = -1
ITEMPS(1) = COMPS(1) + ROUNDE (COMPS(1))
ITEMPS(2) = COMPS(2) + ROUNDE (COMPS(2))
ITEMPS(3) = COMPS(15) + ROUNDE(COMPS(15))
OUT(1) = COMPS(3)
OUT(2) = COMPS(16)
IF(COMPS(9)) 10,10,50
10 OUT(13) = COMPS(10)
OUT(14) = COMPS(11)
OUT(15) = FROM(COMPS(12))
OUT(16) = COMPS(13)
OUT(17) = COMPS(14)
J = J + 7
C-----DETERMINE HOW TO WRITE THE LINE
IF(K.EQ.1HS) GO TO 20
WRITE (6,910) K,ITEMPS,(OUT(1),I=1,J)
910 FORMAT(1X10,2X314,2F6.2,50XF5.2,2XF6.4,2XA3,5XF5.2,6XF5.2)
LINES = LINES - 1
RETURN
C-----CHECK THE LINE COUNTER
20 IF(LINES) 30,30,40
30 WRITE (6,920) FOOTNOT,WSHEOIO,NSUB
920 FORMAT(*0*13A10/1X13A10/*1*54X*WATER BALANCE SIMULATION*/
1 1X6A10,41X*COMPOSITE OF*13,* SUBSTATIONS*/
2 *0*15X*TEMP (F) PRECIP (IN) INTERCEPT RAD (CAL) ENG BAL
3 SNOWPACK INPUT EVAPOTRANS RECHARGE GENERATEO*/
4 5X*DATE MAX MIN AVE DAY ACCUM (IN) SW LW (CA
5L) TEMP(C) WE(IN) (IN) FROM REQ (IN) RUNOFF (IN)*
LINES = MAXLINE
40 WRITE (6,930) DATE,ITEMPS,(OUT(1),I=1,J)
930 FORMAT(* *313,3X314,2F6.2,50XF5.2,2XF6.4,2XA3,5XF5.2,6XF5.2)
LINES = LINES - 1
RETURN
C-----ALL THE INFORMATION IS TO BE PRINTED
50 00 60 I = 3,13
60 OUT(1) = COMPS(1+I)
OUT(11) = FROM(COMPS(12))
J = J + 13
C-----DETERMINE HOW TO WRITE THE LINE
IF(K.EQ.1HS) GO TO 70
WRITE (6,940) K,ITEMPS,(OUT(1),I=1,J)
940 FORMAT(1X10,2X314,2F6.2,5XF6.4,3X3F6.1,4XF4.1,2XF6.2,2XF5.2,2X
1 F6.4,2XA3,5XF5.2,6XF5.2)
LINES = LINES - 1
RETURN
C-----CHECK THE LINE COUNTER
70 IF(LINES) 80,80,90
80 WRITE (6,920) FOOTNOT,WSHEOIO,NSUB
LINES = MAXLINE
90 WRITE (6,950) DATE,ITEMPS,(OUT(1),I=1,J)
950 FORMAT(* *313,3X314,2F6.2,5XF6.4,3X3F6.1,4XF4.1,2XF6.2,2XF5.2,2X
1 F6.4,2XA3,5XF5.2,6XF5.2)
LINES = LINES - 1
RETURN

```

C
C-----YEARLY TOTALS

```

C
ENTRY WRITOT
C-----DETERMINE HOW TO WRITE THE LINE
IF(K.EQ.1HS) GO TO 100
WRITE (6,960) K,(COMPS(1),I=1,5)
960 FORMAT(1X10,20XF6.2,49XF6.2,FB.4,9XF6.2,4XF7.2/)
LINES = LINES - 2
RETURN
C-----CHECK THE LINE COUNTER
100 IF(LINES) 110,110,120
110 WRITE (6,920) FOOTNOT,WSHEOIO,NSUB
LINES = MAXLINE
120 WRITE (6,970) DATE,(COMPS(1),I=1,5)
970 FORMAT(*0TOTALS THROUGH*313,7XF6.2,49XF6.2,FB.4,* (CHNG =*F6.2,*)
1*3XF7.2/)
LINES = LINES - 3
RETURN
END

```

Program DAILYO

```

OVERLAY (OLAYS,3,1)
PROGRAM DAILYO
C-----DAILY COMPOSITE OUTPUT, NO ALTERNATIVES
COMMON AIRTEMC(25,6)
COMMON CALOE(25),COMAX(25),COVOEN(25)
COMMON OREADY(25)
COMMON ENGBAL(25),ET,ETOAILY(25,12)
COMMON FREEWAT(25)
COMMON ISOHRM(25,20)
COMMON LASTUSO(25),LEVEL1,LEVEL2
COMMON MM00
COMMON NOAYSNO(25),NOIVSBL,NSUB,NYEARS
COMMON ONTREES(25)
COMMON PEAKPPT(25,20),PEAKWE(25,20),PHASE(25),POTENT(24),
1 PREWEQV(25)
COMMON RECHRG(25)
COMMON SIMTEMI(25,3),SUBIO(25,6),SLPASP(25,24)
COMMON TC0EFF(25),THRSHLO(25),TOPLOT(11)
COMMON VEGTYPE(25)

```

```

COMMON WEIGHT(25),WSHEOIO(6)
COMMON YEARS(20),YYMMOO
INTEGER OREADY
INTEGER PHASE
INTEGER SUBIO
INTEGER TOPLOT
INTEGER VEGTYPE
INTEGER WSHEOIO
INTEGER YEARS,YYMMOO
COMMON/CMPSITO/COMPS(16),YRTOT(5)
COMMON/FORDATA/ FOOTNOT(26),MAXLINE
INTEGER FOOTNOT
COMMON/MASTER/DATE(3),TMXMSTR,TMNMSTR,PPTMSTR,PPTONOW,OBSHYOR,
1 POTRAD,MSTREOF,IYR
INTEGER DATE
COMMON/PLOTS/PLTOT(11)
COMMON/WATBAL/ETFROM,EVAPOTR,GENRO,PRECIP,RAOIN,RAOLWN,RAOSHN,
1 TEMPMAX,TEMPMIN,WATERIN
INTEGER FOOTNTE(26)
DATA FOOTNTE/260HNORMAL SIMULATION ONLY
1
2
3
4
C-----DEFINE THE FOOTNOTE
DO 1 N = 1,26
1 FOOTNOT(N) = FOOTNTE(N)
C-----MAXLINE = 52 - NUMBER OF ALTERATIONS
MAXLINE = 52
C-----WRITE THE FOOTNOTE ON THE PLOT
WRITE (11,900) FOOTNOT
900 FORMAT(/'0*13A10/1X13A10//)
C-----READ A MASTER CARD
10 CALL ROMSTR
IF(MSTREOF) 20,20,130
C-----GENERATE THE DATA AND PERFORM THE SIMULATIONS FOR EACH SUBSTATION
20 DO 30 N = 1,NSUB
CALL GENDATA (N)
CALL NORM3 (N)
30 CONTINUE
C-----WRITE OUT THE COMPOSITE LINE
COMPS(15) = (COMPS(1) + COMPS(2)) * 0.5
COMPS(16) = COMPS(16) + COMPS(3)
C-----CONVERT THE CALORIE DEFICIT TO A PACK TEMPERATURE
IF(COMPS(9).NE.0.0) COMPS(8) = - COMPS(8)/(COMPS(9) * 1.27)
CALL WRITE3 (1HS,COMPS)
C-----ADD THESE VALUES INTO THE YEARLY TOTALS
YRTOT(2) = YRTOT(2) + COMPS(10)
YRTOT(3) = YRTOT(3) + COMPS(11)
YRTOT(5) = YRTOT(5) + COMPS(14)
C-----STORE THE INFORMATION FOR THE PLOTS
PLOT(1) = OBShYOR

PLOT(2) = COMPS(9)
PLOT(3) = COMPS(10)
PLOT(4) = COMPS(11)
PLOT(5) = COMPS(13)
PLOT(6) = COMPS(14)
C-----PERFORM THE PLOTS BETWEEN APRIL 1 AND SEPTEMBER 30
IF(MMOO - 401) 110,90,40
40 IF(930 - MMOO) 110,50,100
C-----ON 9/30, PRINT THE YEARLY TOTALS, ZERO THE ACCUMULATED PRECIP AND
C----- RESET THE DIFFUSION MODEL SWITCHES
50 YRTOT(1) = COMPS(16)
YRTOT(4) = COMPS(13) - YRTOT(4)
CALL WRITOT (1HS,YRTOT)
YRTOT(4) = COMPS(13)
YRTOT(2) = 0.0
YRTOT(3) = 0.0
YRTOT(5) = 0.0
COMPS(16) = 0.0
DO 60 N = 1,NSUB
60 OREADY(N) = 0
C-----CHECK THE YEARS TO BE SURE ALL DECKS STILL CORRESPOND TO THE
C----- PARAMETER DECK
IF(DATE(3) - YEARS(IYR)) 70,80,70
70 WRITE (6,910) DATE(3),IYR,IYR,YEARS(IYR)
910 FORMAT('1THE DATA DECKS ARE OUT OF PHASE WITH THE WATERSHEO PARAME
1TER DECK. THE WATER YEAR JUST ENDING (19*12,*) IS DECK NUMBER*13,
2 *,*/* BUT SPECIFIED CONDITIONS CARD NUMBER*13,* FOR EACH SUBSTAT
3ION IS FOR 19*12)
CALL EXIT
80 IYR = IYR + 1
GO TO 100
C-----ON 4/1, WRITE THE ORINATE LINE
90 WRITE (11,920)
920 FORMAT(9X124(1H.))
C-----PERFORM THE PLOT, THEN ZERO THE COMPOSITE LOCATIONS
100 CALL PLOTTER
110 DO 120 N = 1,14
120 COMPS(N) = 0.0
GO TO 10
C-----ALL CARDS HAVE BEEN READ. IF THE DECK ENDED ON 9/30, ALREADY
C----- CAUSING THE WATER YEAR TOTALS TO PRINT, JUST END THE JOB. BUT ON
C----- ANY OTHER DAY, PRINT OUT THE YEAR TO DATE TOTALS HERE
130 IF(MMOO - 930) 140,150,140
140 YRTOT(1) = COMPS(16)
YRTOT(4) = PLOT(5) - YRTOT(4)
CALL WRITOT (1HS,YRTOT)
C-----WRITE THE FOOTNOTE ON THE LAST PAGE
150 WRITE (6,930) FOOTNOT
930 FORMAT('0*13A10/1X13A10)
C-----RETURN TO THE MAIN OVERLAY FOR NORMAL TERMINATION
END

```


Leaf, Charles F., and Glen E. Brink.

1973. Hydrologic simulation model of Colorado subalpine forest. USDA For. Serv. Res. Pap. RM-107, 23p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 80521.

A simulation model specifically designed to determine the probable hydrologic changes resulting from watershed management in the Colorado subalpine zone is described. The model simulates the total water balance on a continuous year-round basis and compiles the results from individual hydrologic response units into a "composite overview" of an entire drainage basin. Preliminary results are summarized for an 8-year test period on a 667-acre experimental watershed.

Oxford: 116.21:U681.3. **Keywords:** Computer models, coniferous forest, forest management, model studies, simulation analysis, snowmelt, subalpine hydrology, vegetation effects, watershed management.

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