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COMPUTER SIMULATION OF SNOWMELT WITHIN A COLORADO SUBALPINE WATERSHED

by Charles F. Leaf and Glen E. Brink

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Abstract

A dynamic model which simulates snowmelt in Colorado sub-alpine watersheds for all combinations of aspect, slope, elevation, and forest cover composition and density is described. The model simulates winter snow accumulation, the energy balance, snowpack condition, and resultant melt in time and space. Detailed flow chart descriptions of the various components of the model and a program listing are presented.

Keywords: Computer models, coniferous forests, model studies, simulation analysis, snowmelt, watershed management.

**COMPUTER SIMULATION OF
SNOWMELT WITHIN A COLORADO
SUBALPINE WATERSHED**

by

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¹*Central headquarters maintained at Fort Collins in cooperation with Colorado State University. Research reported here was conducted and partly financed in cooperation with the Division of Atmospheric Water Resources Management, Bureau of Reclamation, U.S. Department of the Interior.*

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Computer Simulation of Snowmelt Within a Colorado Subalpine Watershed

Charles F. Leaf and Glen E. Brink

The systems approach is a way to determine the probable effects of land management on the many interdependent hydrologic components in the Colorado subalpine forest. Accordingly, we are developing mathematical models to simulate the hydrology of this high-elevation ecosystem.

As a first step, we are modeling: (1) winter snow accumulation, (2) the energy balance, (3) snowpack condition, and (4) resultant melt in time and space under a variety of conditions. Combinations of aspect, slope, elevation, and forest cover composition and density are included. The computer program described was initially written by the Watershed Systems Development Unit at the Pacific Southwest Forest and Range Experiment Station (Willen et al. 1971). We have revised the original program to better represent conditions in the Rocky Mountain region. With this snowmelt model, we have simulated the probable effects of forest cover manipulation and additions to the winter snowpack through weather modification.

The model consists of three parts: (1) the determination of the form of precipitation (rain or snow), (2) the melting process, and (3) snowpack condition in terms of energy level and free water requirements. Shortwave and longwave radiation represent the energy available for snowmelt. In the forested environment, shortwave radiation reaching the pack is estimated by means of a transmissivity coefficient function, which depends on the density and composition of the forest cover (Miller 1959, Reifsnyder and Lull 1965). Radiation inputs are adjusted for slope and aspect (Frank and Lee 1966). Reflectivity of the snowpack is varied according to precipitation, the energy balance, and time (U.S. Army 1956).

The snowpack is assumed to behave as a dynamic heat reservoir; thus all elements in the snowmelt portion of the model are expressed in units of heat. The net external energy balance is computed at the snow

surface. Rain and snow are converted from inches at the prevailing air temperature to equivalent gram-calories. Each precipitation event is added algebraically as a caloric-heat event to develop the heat reservoir or snowpack. Temperatures within the snowpack are computed using unsteady heat flow theory. The snowpack will yield melt water only when it has reached a zero energy deficit (snowpack temperature = 0°C) and its free water holding capacity is satisfied. Snowmelt rates after the pack is primed are governed primarily by the longwave and shortwave energy balances at the snow surface. The discussion which follows is a detailed flow chart description of the various components of the model. The model has been programed for the CDC 6400 computer² at Colorado State University.

Program Description

Program MELTMOD (Main Program)

The main program (fig. 1) makes no computations, but serves only to coordinate the flow of the program. Within the listing of the main program is included a dictionary of all variables that are available for use and cross referencing by the subroutines as well as the main program. (This allocation of computer memory for mutual access by many routines is designated "blank common.") Other dictionaries appear throughout the subroutines for variables used exclusively within those routines. Blank common is arranged so that additional variables may be added easily; by using a very extensive blank common, the routines were broken down into simpler logical units rather than one or two

²The use of trade and company names is for the benefit of the reader; such use does not constitute an official endorsement or approval of any service or product by the U. S. Department of Agriculture to the exclusion of others that may be suitable.

Figure 1.

large routines. The model contains 10 subroutines, discussed in the following order:

1. AFFECTS	6. LINK
2. CALIN	7. MIXTURE
3. CALOSS	8. RADBAL
4. DIFMOD	9. RAINED
5. GETREF	10. SNOWED

The parameters which describe the initial conditions in the model are solar radiation transmissivity coefficient, forest cover density, an initial pack temperature and water equivalent, and a threshold value for use in the reflectivity subroutine, GETREF. The data items supplied on a daily basis for the simulation are incoming shortwave radiation, daily maximum and minimum temperatures, observed water equivalent (optional), precipitation, and density of the snowpack (optional). Observed snowpack temperatures for use by the diffusion model, subroutine DIFMOD, are also optional, but recommended.

1. Subroutine AFFECTS (fig. 2)

The decisions necessary to compute the response to input data are started within this routine and continued in other routines. The primary decision to be made here is the classification of a precipitation event. An event is classified as follows:

- If the daily minimum temperature is less than or equal to 32°F , or if the daily maximum temperature is less than or equal to 35°F , it is a snow event.
- If the minimum temperature is greater than 35°F , it is a rain event.
- If the minimum temperature is between 32°F and 35°F , and the maximum temperature is greater than 35°F , it is a mixture of rain and snow event. The total precipitation is partitioned into rain and snow by the formula presented in subroutine MIXTURE.

The precipitation is added to the snowpack, and the caloric input or loss due to the precipitation is calculated. Effects on the snowpack are computed by subroutines

Figure 2.

CALIN or CALOSS. Subroutines GETREF and RADBAL are then called to compute the reflectivity of the pack, and the influences of the radiation balance as computed from air temperature.

2. Subroutine CALIN (fig. 3)

This routine computes the effects of caloric input from either the radiation balance or from rainfall. A check is made to see if the input satisfies an exisiting calorie deficit, given by the equation

$$CALDEF = 203.2 W_c \tag{1}$$

where

CALDEF = heat deficit of thesnowpack in calories, and

W_c = the “cold content” which represents the heat required to raise the snowpack to 0° C, in equivalent inches of water (U.S. Army 1960).

Figure 3.

If the input energy is not sufficient to make up the heat deficit, the only action taken is to adjust the pack temperature to compensate for the input. If the calorie deficit is satisfied and there is still sufficient input to generate melt, the melt is added to the free water content of the snowpack and deleted from the ice content. A new free water holding capacity is then computed (4 percent by weight of the ice content) and any excess free water is deleted from the pack.

3. Subroutine CALOSS (fig. 4)

This routine computes the effects of a loss of energy from the pack. The loss may be due to either a negative radiation balance (the back radiation exceeding incoming radiation). or “cold content” added by precipitation (fresh snow). The snowpack is first examined to see if any free water is present in the pack; if not, the calorie deficit is increased to compensate for the loss. If free water is present, the loss is used to freeze all or part of it (80 calories per cm. of free water). If the loss is more than sufficient to freeze all of the free water the remaining heat loss is used to create a calorie deficit (eq. 1).

Figure 4.

4. Subroutine DIFMOD (fig. 5)

This routine controls the snowpack temperature through the winter months. Because the snowpack is typically below 0° C during much of the snow accumulation season, heat flow theory is used to index its thermal regime.

Total heat energy input to the snowpack is represented by air temperature measured 3 to 4 feet above the snow surface. The temperature in this boundary layer region is assumed to be an integration of all the processes involved, including incoming and outgoing radiation, wind, temperature, and humidity in the overlying airmass. The heat flow equation as solved by this routine is given by Quick (1967) and Riley et al. (1969):

$$k_s \frac{\partial^2 T_s}{\partial z^2} = c_s \rho_s \frac{\partial T_s}{\partial t} \quad [2]$$

where

k_s = thermal conductivity in cal/°C/cm/sec,
 c_s = specific heat in cal/gm/°C,
 ρ_s = snowpack density in gm/cm³,
 T_s = snowpack temperature in °C,
 z = depth within snowpack (from surface) in cm., and
 t = time in sec.

Equation [2] can be rewritten as:

$$\frac{\partial^2 T_s}{\partial z^2} = K_v \frac{\partial T_s}{\partial t} \quad [3]$$

where

K_v = thermal diffusivity in cm²/sec.

The thermal diffusivity is assumed to vary with density according to the relation proposed by Schwerdtfeger (1963):

$$K_v = \frac{2 k_i}{(3\rho_i - \rho_s)c_i} \quad [4]$$

where

k_i = thermal conductivity of ice in cal/°C/cm/sec.,
 ρ_i = density of ice in gm/cm³, and
 c_i = specific heat of ice in cal/gm/°C.

Figure 5.

The density is assumed to be constant throughout the pack, although it may vary with time.

A finite difference solution for equation [3] is obtained as follows (Smith 1965, Richtmyer and Morton 1967):

Let

$$\frac{\partial u}{\partial t} = \sigma \frac{\partial^2 u}{\partial x^2} \quad \sigma = \text{const.} > 0 \quad [5]$$

where equation [5] is the nondimensional form of equation [3]. (It should be noted that the number representing the depth of the pack is 1.)

The forward difference approximation to equation [5] is given by

$$\frac{u_{i,j+1} - u_{i,j}}{m} = \frac{u_{i+1,j} - 2u_{i,j} + u_{i-1,j}}{h^2} \quad [6]$$

where

$x = ih, (i = 0, 1, 2, \dots)$
 $t = jm (j = 0, 1, 2, \dots)$

Equation [6] can be written as:

$$u_{i,j+1} = u_{i,j} + \frac{mK_v}{h^2} (u_{i-1,j} - 2u_{i,j} + u_{i+1,j}) \quad [7]$$

which gives the explicit solution for the unknown temperature $u_{i,j+1}$ at the $(i,j+1)$ th mesh point in terms of known temperatures along the j th time row. Hence, it becomes possible to calculate the unknown pivotal values of u along the first time row, $t = m$ (fig. 6) in terms of known boundary and initial values along $t = 0$, then the unknown pivotal values along the second time row in terms of the calculated pivotal values along the first, and so forth.

Equation [7] utilizes the average air temperature (assumed to be the temperature of the surface of the snowpack), ground temperature, and temperature at the midpoint of the snowpack during the previous interval to

simulate present snowpack temperature. The midpoint temperature is defined initially from observed data and simulated thereafter. The diffusion model has been found to be mathematically stable only for reasonably deep packs (≥ 4.7 inches of water equivalent). To insure stability in the model, each 24-hour period is divided into two 12-hour intervals and the result is averaged. The average air temperatures for each 12-hour interval are the "high average" (the mean of the maximum and daily mean temperatures) and the "low average" (the mean of the minimum and daily mean temperatures.)

Once the snowpack becomes isothermal, subroutine RADBAL computes the energy balance. Subroutine LINK determines when the diffusion model is to be used and when the radiation balance is to be used. The diffusion model may be initialized or readied by external controls or when the radiation balance creates a calorie deficit.

Figure 6.

5. Subroutine GETREF (fig. 7)

This routine selects the reflectivity for use in the radiation balance routine, RADBAL. In essence, there are two functions from which the reflectivity is selected: one for the accumulation phase of the snowpack and one for the melt phase (U.S. Army 1960). The reflectivity is assumed to start at a higher value and to decrease more slowly with time during accumulation than during the melt season. To determine which function to use, a check is made on the following conditions:

- If no new snow was added to the pack during a given day, the length of time since fresh snow is increased by 1 day and the function used on the previous day is used again. The accumulation function computes reflectivity for 15 consecutive days. After 15 days, control shifts to the next lower value in the melt function, which computes reflectivity for an additional 26 days. After this period of time, the reflectivity is a constant 40 percent. The minimum value for the reflectivity in any case is assumed to be 40 percent.
- If new snow has fallen on the pack, a further check is made to see if it was a "spring" or "winter" snow. This is determined by comparing the maximum daily temperature against a temperature threshold which varies according to elevation, forest cover, and aspect. If it is warmer than the threshold, no change is made and the control flows as explained in part a. If it is colder, indicating "winter" snow conditions, another check determines if the snowpack is isothermal and thus selects which function to use while re-initializing the day counter.

6. Subroutine LINK (fig. 8)

This routine is the interface between the thermal diffusivity model and the radiation balance routine. As discussed above, the diffusion model is used to control the snowpack temperature during the winter season. Air temperature is the driving variable in both routines, so they are somewhat related. The decision as to which method to use is basically dependent on whether the snowpack is still under "winter" conditions or "spring"

Figure 7.

conditions. The first check is to see if the radiation balance has simulated a caloric gain or loss from the pack. A loss requires a check to see if the pack has been isothermal with free water content ("spring") or if it has been cold ("winter"). If it was already cold, the diffusion model is used without further question. If the pack did contain free water, the loss is used to freeze it and, if a calorie deficit would be created, the diffusion model is re-initialized to isothermal conditions and the radiation balance is adjusted accordingly. In the event of a caloric gain, a check is made to see if the calorie deficit would be satisfied; if not, the diffusion model is used. If the deficit is satisfied, a further check is made to see if at least 0.05 inch of free water is generated; if not, the diffusion model is set to isothermal conditions and control passes to the diffusion model. However, if sufficient free water is generated, the diffusion model is turned off and the radiation balance resumes full control.

Figure 8.

passes to the subroutines that make the computations for a snow event and a rain event.

Figure 9.

7. Subroutine MIXTURE (fig. 9)

This routine partitions rain and snow precipitation components which fall on days when the maximum temperature is greater than 35° F and the minimum temperature is greater than 32° F, but less than 35° F. The partitioning is performed through the following equation:

$$\text{SNOW} = (\text{PRECIP}) (1 - B/A) \quad [8]$$

where

- B = the difference between the maximum temperature and 35°,
- A = the difference between the maximum and minimum temperatures.

The "average" temperature for the snow period is computed as the mean of the minimum temperature and 35°, while that for rain is the mean for the maximum and 35°. Control then

8. Subroutine RADBAL (fig. 10)

This routine uses air temperature to compute the net radiation balance through the Stefan-Boltzmann function as follows:

$$L_P = \sigma T^4 \quad [9]$$

where

- L_P = potential longwave radiation at a given temperature,
- σ = Stefan-Boltzmann constant for a 24-hour period:
 $1.17 \times 10^{-7} \text{ (langleys)/(day)/} (^{\circ}\text{K})^{-4}$, and
- T = temperature in °K.

The shortwave radiation component in the radiation balance is computed as a simple function of the transmissivity coefficient and

the cover density. Solar radiation is adjusted for slope and aspect, according to tables published by Frank and Lee (1966). The downward longwave component is computed by using the average air temperature in the Stefan-Boltzmann function according to the equations:

From sky to snow:

$$L_s = \alpha (1 - C_D) (1.17 \times 10^{-7}) (T_A)^4 \quad [10]$$

where

C_D = forest cover density expressed as a decimal,

T_A = ambient air temperature in °K, and

α = a factor (1 or 0.75) which accounts for clear or cloudy skies.

From forest cover to snow:

$$L_F = 1.17 \times 10^{-7} C_D T_F^4 \quad [11]$$

where

T_F = radiation temperature of foliage in °K.

Figure 10.

The upward component (back radiation) is computed by using either the average daily air temperature ("winter" conditions) or the minimum air temperature ("spring" conditions) for the radiation temperature of the snowpack. In the case of the back radiation, however, the temperature used must be less than or equal to 0° C. The equations used are:

From snowpack to forest:

$$L_{SF} = 1.17 \times 10^{-7} C_D T_S^4 \quad [12]$$

where

T_S = radiation temperature of the snowpack in °K.

From snowpack to sky:

$$L_{SS} = (1 - C_D) (1.17 \times 10^{-7}) (T_S)^4 \quad [13]$$

Once the upward and downward components have been calculated, they are combined to get a net longwave balance as follows: if the skies are clear (no precipitation), only 75 percent of the downward longwave radiation given by equation [10] is combined with the back radiation from the snowpack (U.S. Army 1960). The radiation balance under the forest canopy is computed by equations [11] and [12]. During "winter" conditions, $T_F = T_S$ and $L_F = L_{SF}$. If there was precipitation, a check is made to see if it was snow. When there is snow, the longwave balance is assumed to be zero. Otherwise, under cloudy skies, the downward component and the back radiation are merely combined algebraically.

Once the net radiation is computed, the decision is made by the linking routine to use either the diffusion model or the radiation balance. The effects of the decision are then computed by either Subroutine CALIN or Subroutine CALOSS, depending upon the net gain or loss registered by the radiation balance.

9. Subroutine RAINED (fig. 11)

This routine computes the effects of a rain event on the snowpack according to the equation:

$$L_W = (C_R) (\Delta T) (P_R) \quad [14]$$

L_W = calorie gain due to rainfall
 C_R = specific heat of water: 1 cal./gm/° C ,
 ΔT = difference between temperature (°C)
 at which rain falls and 0° C , and
 P_R = amount of rainfall in centimeters.

If the pack is cold, the caloric input from the rain is used to satisfy all or part of the calorie deficit. If the input more than satisfies the deficit, the remainder is contributed as free water and the caloric input from that remaining is allowed to generate other melt. If the pack was already isothermal, the entire amount of rain is added to the pack as free water, and the calories contribute to the melt rate.

10. Subroutine SNOWED (fig. 12)

This routine computes the effects of a snow event on the snowpack according to the equation

$$L_I = (C_S)(\Delta T)(P_S) \quad [15]$$

where

L_I = calorie gain or loss due to snowfall,
 C_S = specific heat of ice: 0.5 cal./gm/° C ,
 ΔT = difference between temperature (° C)
 at which snow falls and 0° C , and
 P_S = water equivalent of snowfall in centimeters.

If the snow falls within the "warm" range of 32° to 35° F, no action is taken concerning the caloric loss. However, snow falling at lower temperatures increases the calorie deficit, and this change is accounted for.

Unlisted Routines

The routines listed below are not included in the flow-charted descriptions since they are merely utility routines for handling input, output, or internal processing of the information. They are not part of the model; rather, they are the necessary routines to implement the model on a digital computer.

INITIAL	RDPACK	STORE
PLOTTER	READER	WRITER

A complete listing of the snowmelt model as described above is included in appendix I.

Model Verification

The model has been tested on field data obtained from the 667-acre Deadhorse Creek watershed (fig. 13) at the Fraser Experimental Forest (Leaf 1971). Snowmelt rates at eight locations on Deadhorse Creek were reconstituted (fig. 14). Agreement between observed and simulated melt rates was good at all locations. The model is structured so that a minimum number of variables must be adjusted to obtain a satisfactory fit. In this case, only two variables were adjusted to obtain satisfactory agreement: (1) cover density (a vegetation type and composition parameter), and (2) a shortwave radiation transmissivity coefficient. Figure 15 compares observed and simulated snowpack accumulation and melt at the high-elevation north slope and low-elevation south slope sites on Deadhorse Creek in 1969. Table 1 is an example of the computer output.

With the cover density and transmissivity coefficients fixed as determined in 1969, the model has given good results in simulating snowmelt on Deadhorse Creek for the 1964-71 runoff seasons. Although it is a simplification of the real life system, the model produces reliable results.

Empirical studies have shown that various watershed management practices exert a significant effect on snowmelt rates and resultant streamflow. Because the model described here is a mechanistic representation of the snowmelt process, its careful use should enable the resource manager to better understand how a given management alternative will affect snowmelt **before** it is implemented. We believe it to be a useful tool for predicting the probable effects of land management practices on the timing and amount of snowmelt.

Figure 13. — Aerial view (foreground) of Deadhorse Creek watershed, Fraser Experiment Forest. The north-facing slope is in the lower lefthand corner of the photograph.

DEADHORSE CREEK

Figure 14. — Locations where field measurements were taken on Deadhorse Creek.

Figure 15. — Observed and simulated snowmelt on upper north (A) and lower south (B) slopes during 1969 snowmelt runoff season.

TABLE 1
SNOWMELT RUNOFF SIMULATION MODEL
FRASER EXPERIMENTAL FOREST, COLORADO
DEACON CREEK, UPPER NORTH SLOPE

TRANSMISSIVITY COEFFICIENT = .25

COVER DENSITY = .55

DATE	TEMPERATURE MAX	MIN	(F) AVE	PRECIP DAY	(IN) ACCUM	NET RAO SHORT	(CAL) LONG	ENERGY BAL (CAL)	SNOWPACK TEMP (C)	PREDICTED W.E. (IN)
4 7 69	30.0	12.0	21.0	0.11	13.45	8.3	-7.3	0.1	-1.0	13.45
4 8 69	32.0	13.0	22.5	0.00	13.45	13.5	-18.0	-4.5	-1.3	13.45
4 9 69	36.0	18.0	27.0	0.00	13.45	29.4	-49.5	-20.1	-2.4	13.45
4 10 69	40.0	23.0	31.5	0.00	13.45	30.7	-21.3	9.5	-1.9	13.45
4 11 69	45.0	27.0	36.0	0.00	13.45	25.7	-20.6	5.1	-1.6	13.45
4 12 69	34.0	25.0	29.5	.29	13.74	8.9	-5.6	2.8	-1.4	13.74
4 13 69	33.0	23.0	28.0	0.00	13.74	28.4	-22.4	6.1	-1.0	13.74
4 14 69	36.0	22.0	29.0	0.00	13.74	31.4	-30.8	.6	-1.0	13.74
4 15 69	40.0	20.0	30.0	.76	14.50	24.2	-30.8	-7.7	-1.4	14.50
4 16 69	28.0	15.0	21.5	.11	14.61	3.1	-.7	1.5	-1.3	14.61
4 17 69	32.0	15.0	23.5	0.00	14.61	22.9	-22.4	.6	-1.3	14.61
4 18 69	40.0	16.0	28.0	0.00	14.61	23.7	-24.7	-1.0	-1.3	14.61
4 19 69	44.0	22.0	33.0	0.00	14.61	34.3	-32.0	2.3	-1.2	14.61
4 20 69	47.0	17.0	32.0	0.00	14.61	38.6	-36.6	2.0	-1.1	14.61
4 21 69	53.0	30.0	41.5	0.00	14.61	40.3	-38.0	2.4	-1.0	14.61
4 22 69	45.0	33.0	39.0	0.00	14.61	34.1	-22.5	11.6	-.3	14.61
4 23 69	55.0	32.0	43.5	.52	15.13	37.4	-31.1	6.2	0.0	15.13
4 24 69	52.0	24.0	38.0	0.00	15.13	45.7	-1.0	44.7	0.0	15.13
4 25 69	24.0	9.0	16.5	0.00	15.13	36.5	-27.4	9.1	0.0	15.13
4 26 69	20.0	8.0	14.0	.14	15.27	16.9	0.0	15.1	0.0	15.27
4 27 69	27.0	8.0	17.5	0.00	15.27	33.0	-18.5	14.5	0.0	15.27
4 28 69	38.0	15.0	26.5	0.00	15.27	45.0	-11.2	33.7	0.0	15.27
4 29 69	42.0	22.0	32.0	0.00	15.27	48.3	-19.8	28.5	0.0	15.13
4 30 69	47.0	26.0	36.5	0.00	15.27	56.6	-18.5	38.1	0.0	14.94

ELEVATION 10500 FT.
ASPECT NE, SLOPE 35 PERCENT

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Appendix I: Complete Listing of Snowmelt Model

Program MELTMOD

```

PROGRAM MELTMOD (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
C-----THIS IS A REWRITTEN VERSION OF -SNMELT-, A SNOW ACCUMULATION MODEL
C-----DEVELOPED BY THE U. S. FOREST SERVICE AT BERKELEY. THE RADIATION
C-----BALANCE, AS DERIVED FROM AIR TEMPERATURE, SERVES AS THE MODEL
C-----PARAMETERS AND CHARACTERISTICS.
C-----
C-----DICTIONARY OF BLANK COMMON
C-----
C ACTDATE - THE DATE OF THE RECORDING OF THE VALUES IN -ACTUAL-
C ACTUAL - THE OBSERVED SNOWPACK TEMPERATURES USED TO INITIALIZE THE
C DIFFUSION MODEL (SUBROUTINE DIFMOD). LOCATIONS 1
C THROUGH 19 ARE THE OBSERVED TEMPERATURES AND LOCATION
C 20 IS THE GROUND TEMPERATURE (-XX.X DEGREES C).
C LOCATION 21 IS THE DISTANCE BETWEEN THE MEASURED
C SNOWPACK TEMPERATURES (XX.X INCHES - USUALLY 6 IN.)
C AVETEMC - THE DEGREES CENTIGRADE EQUIVALENT OF -AVETEMF-
C AVETEMF - MEAN OR AVERAGE OF THE MAXIMUM AND MINIMUM TEMPERATURE
C IN DEGREES FARENHEIT
C BASTEMF - BASE TEMPERATURE DEGREES FARENHEIT, RAIN TURNS TO SNOW
C CALAIR - POTENTIAL LONGWAVE CALORIC INPUT AT AIR TEMPERATURE
C CALOEF - THE CALORIE 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 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 COVOEN - THE COVER DENSITY IS THE FRACTION OF THE GROUND OR SNOW
C SURFACE SHADED FROM DIRECT SUNLIGHT OR RADIATION
C DATE - THE DATE BEING PROCESSED IN MMDDYY FORMAT
C DATES - AN ARRAY OF THE DATE BEING PROCESSED. THE FIRST WORD IS
C THE MONTH, THE SECOND THE DAY, AND THE THIRD THE YEAR
C DEN - THE SNOWPACK DENSITY READ FROM INPUT CARDS
C DENSITY - THE DENSITY OF THE SNOWPACK USED IN THE DIFFUSION MODEL.
C IF -DEN- IS ZERO OR BLANK, -DENSITY- IS COMPUTED AS A
C FUNCTION OF THE PREDICTED WATER EQUIVALENT
C DREADY = 0, DIFFUSION MODEL (SUBROUTINE DIFMOD) NOT INITIALIZED
C = 1, DIFFUSION MODEL INITIALIZED AND READY FOR SNOWPACK
C TEMPERATURE SIMULATION
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, - CALORIE-
C FOOTNOT - ARRAY OF FOOTNOTES TO BE PRINTED AT THE BOTTOM OF EACH
C PAGE. TWO CARDS ARE READ, THE FIRST 130 CHARACTERS
C FORMING ONE LINE AND THE LAST 30 CHARACTERS FORMING A
C SECOND LINE
C FREEWAT - THE FREE WATER BEING HELD BY THE SNOWPACK
C HOLOCAP - THE FREE WATER HOLDING CAPACITY OF THE SNOWPACK
C (ASSUMED TO BE FOUR PERCENT OF THE WATER EQUIVALENT)
C IOATE - ARRAY FOR STORING THE DATES FOR PLOTTING
C ISNOW - A SWITCH TURNED ON BY SUBROUTINE SNOWED WHEN THE PRECIP
C WAS SNOW AND THEN OFF BY SUBROUTINE GETREF AFTER
C COMPUTING THE REFLECTIVITY FOR THE GIVEN INTERVAL
C ITABLE = 0, NO PRINTING OF TABULATED RESULTS FROM THE SIMULATION
C = 1, PRINT THE TABULATED RESULTS FROM THE SIMULATION
C KOUNT - COUNTER FOR THE NUMBER OF CARDS READ, MAXIMUM OF 372 DUE
C TO THE DIMENSIONS OF THE VARIABLES FOR STORING THE
C INFORMATION FOR PLOTTING
C LASTUSD - AN INDICATOR USED IN SUBROUTINE GETREF TO DETERMINE
C WHICH REFLECTIVITY FUNCTION TO USE
C LINES - THE LINE COUNTER FOR PAGE EJECTION
C NEXTACT - A ONE COLUMN CODE (COL 70) ON THE INPUT CARDS TO
C INDICATE WHEN A CARD CONTAINING THE ACTUAL SNOWPACK
C TEMPERATURES IS TO BE READ. WHEN COLUMN 70 IS NOT
C BLANK OR ZERO, CONTROL SHIFTS TO SUBROUTINE ROPACK
C WHICH THEN READS THE NEXT CARD
C OBSWEQV - OBSERVED WATER EQUIVALENT OF THE SNOWPACK IN INCHES
C PACKTEM - THE EFFECTIVE TEMPERATURE OF THE SNOWPACK
C PARTICE - THE PORTION OF THE PREDICTED WATER EQUIVALENT THAT IS
C ICE. THIS QUANTITY PLUS FREE WATER IS THE TOTAL
C PREDICTED WATER EQUIVALENT (-PREWEQV-)
C PASTINT - NUMBER OF INTERVALS SINCE THE LAST INITIALIZATION OF THE
C REFLECTIVITY FUNCTION
C PLOTBS = 0, DO NOT PLOT THE OBSERVED WATER EQUIVALENT
C 1, PLOT THE OBSERVED WATER EQUIVALENT (OPERATIVE ONLY IF
C -PLOTWE- IS TURNED ON)
C PLOTWE = 0, DO NOT PLOT THE SIMULATION
C = 1, PLOT THE SIMULATION, PRECIP, ETC.
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 RAOSWN - THE CALORIC INPUT TO THE PACK BY THE NET SHORT WAVE
C RADIATION
C REFLECT - THE FRACTION OF RADIATION THAT IS REFLECTED BY THE SNOW
C AS DERIVED BY SUBROUTINE GETREF
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 #1; NODE MIDWAY

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C BETWEEN THE SURFACE AND THE GROUND, AND LOCATION 3 IS
C THE GROUND TEMPERATURE.
C SIMTEM2 = THE SNOWPACK TEMPERATURE AT THE MIDDLE NODE FOR THIS
C INTERVAL, AS SIMULATED BY SUBROUTINE DIFMOD
C SIMTEM3 = THE AVERAGE SNOWPACK TEMPERATURE FOR THIS INTERVAL, AS
C DERIVED BY SUBROUTINE DIFMOD
C SNMELT - MELT DELIVERED IN INCHES FOR THE INTERVAL
C SOBSEQV - ARRAY FOR STORING THE OBSERVED WATER EQUIVALENT FOR
C PLOTTING
C SPRECIP - ARRAY FOR STORING THE PRECIP FOR PLOTTING
C SPREQV - ARRAY FOR STORING THE PREDICTED WATER EQUIVALENT FOR
C SUBTITL - ONE CARD SUBTITLE, SIMILAR TO -TITLE-
C TCDEFF - THE TRANSMISSIVITY COEFFICIENT USED TO ESTIMATE THE NET
C SHORT WAVE RADIATION REACHING THE SNOWPACK. SEE
C REIFSNVOER 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 THRSLO - 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 TITLE - ONE CARD TITLE (IF THE INFORMATION IS CENTERED ON THE CARD
C IT WILL BE PROPERLY CENTERED ON THE PAGE)
C TOTPREC - THE ACCUMULATED TOTAL PRECIPITATION IN INCHES
C USEMEAN = 0, USE MAXIMUM AND MINIMUM TEMPERATURES AS READ
C = 1, REPLACE THE MAXIMUM AND MINIMUM TEMPERATURES BY THEIR
C MEAN
C XMAX - MAXIMUM OBSERVED OR PREDICTED WATER EQUIVALENT, USED FOR
C SCALING
C-----
COMMON ACTDATE,ACTUAL(21),AVETEMC,AVETEMF
COMMON BASTEMF
COMMON CALAIR,CALOEF,CALORIE,CALSNOW,COVOEN
COMMON DATE,DATES(3),DEN,DENSITY,OREADY
COMMON ENGBAL
COMMON FOOTNOT(16),FREEWAT
COMMON HOLOCAP
COMMON IOATE(372),ISNOW,ITABLE
COMMON KOUNT
COMMON LASTUSD,LINES
COMMON NEXTACT
COMMON OBSWEQV
COMMON PACKTEM,PARTICE,PASTINT,PLOTBS,PLOTWE,PRECIP,PREWEQV
COMMON RADIN,RADLWN,RADSNW,REFLECT
COMMON SIMTEM1(3),SIMTEM2,SIMTEM3,SNMELT,SOBSEQV(372),
1 SPRECIP(372),SPREQV(372),SUBTITL(8)
COMMON TCDEFF,TEMPMAX,TEMPMIN,THRSLO,TITLE(8),TOTPREC
COMMON USEMEAN
COMMON XMAX
INTEGER ACTDATE
INTEGER DATE,DATES,OREADY
INTEGER FOOTNOT
INTEGER PASTINT,PLOTBS,PLOTWE
INTEGER SUBTITL
INTEGER TITLE
INTEGER USEMEAN
COMMON/CONVERT/FIVE9TH,THIRTY2
DATA FIVE9TH,THIRTY2/,555555556,32.D/
C-----INITIALIZE THE MODEL AND READ THE PARAMETER CARDS
10 CALL INITIAL
C-----READ A DATA CARD
20 CALL READER (IENO)
C-----A BLANK CARD MAY BE USED TO SEPARATE SETS OF DATA
IF(IENO.NE.D.OR.DATE.LE.D) GO TO 60
C-----SEE HOW THIS INTERVAL AFFECTS THE SIMULATION
CALL AFFECTS
C-----IF THE TABLE IS BEING PRINTED, WRITE THIS LINE
IF(ITABLE) 40,40,30
30 CALL WRITER
C-----IF THE PLOT IS TO BE DONE, STORE THIS INFORMATION. THEN GO ON TO
C-----THE NEXT CARD
40 IF(PLOTWE) 20,20,50
50 CALL STORE
GO TO 20
C-----ALL CARDS HAVE BEEN READ, SO PLOT THE SIMULATION AFTER WRITING
C-----THE FOOTNOTES ON THE LAST PAGE
60 IF(ITABLE.NE.D) WRITE (6,910) FOOTNOT
70 FORMAT(1H013A10/1X3A10)
IF(PLOTWE.NE.D) CALL PLOTTER
C-----IF THE END OF FILE HAS NOT BEEN SENSED, GO ON TO THE NEXT SET OF
C-----DATA
IF(IENO) 70,10,70
70 STOP
END
Subroutine AFFECTS
SUBROUTINE AFFECTS
C-----DETERMINE THE EFFECTS OF THE DATA FROM THIS CARD
COMMON ACTDATE,ACTUAL(21),AVETEMC,AVETEMF
COMMON BASTEMF
COMMON CALAIR,CALOEF,CALORIE,CALSNOW,COVOEN
COMMON DATE,DATES(3),DEN,DENSITY,OREADY
COMMON ENGBAL
COMMON FOOTNOT(16),FREEWAT
COMMON HOLOCAP

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CDMMON IDATE(372),ISNDW,ITABLE
CDMMON KOUNT
CDMMON LASTUSD,LINES
CDMMON NEXTACT
CDMMON OBSWEQV
CDMMON PACKTEM,PARTICE,PASTINT,PLOTDBS,PLOTWE,PRECIP,PREWEQV
CDMMON RADIN,RADLWN,RAOSWN,REFLECT
CDMMON SIMTEM1(3),SIMTEM2,SIMTEM3,SNOMELT,SOBSEQV(372),
1 SPRECIP(372),SPREQV(372),SUBTITL(8)
CDMMON TCDEFF,TEMPMAX,TEMPMIN,THRSHLD,TITLE(8),TOTPREC
CDMMON USEMEAN
CDMMON XMAX
INTEGER ACTDATE
INTEGER DATE,OATES,DREADY
INTEGER FOOTNOT
INTEGER PASTINT,PLOTDBS,PLOTWE
INTEGER SUBTITL
INTEGER TITLE
INTEGER USEMEAN
CDMMON/CONVERT/FIVE9TH,THIRTY2
C-----START THE ENERGY BALANCE AND SNOWMELT AT ZERO FOR THIS INTERVAL,
C-----BUT ACCUMULATE THE PRECIPITATION
ISNDW = D
ENGBAL = D.0
SNOMELT = D.0
TOTPREC = TOTPREC + PRECIP
C-----IF A SNOWPACK ALREADY EXISTS, GO FIND THE EFFECT OF THIS INTERVAL
C-----ON THE SNOWPACK
IF(PREWEQV) 10,10,40
C-----SINCE THERE IS NO SNOWPACK, CHECK TO SEE IF THIS INTERVAL HAS ANY
C-----PRECIPITATION AND IF SO, SEE IF IT IS ALL SNOW
10 IF(PRECIP) 120,120,20
C-----IF THE MINIMUM TEMPERATURE IS BELOW FREEZING, CONSIDER THE
C-----PRECIPITATION TO BE ALL SNOW
20 IF(TEMPMIN.LE.THIRTY2.DR.TEMPMAX.LE.BASTEMF) GO TO 60
C-----SEE IF THE PRECIPITATION IS ALL RAIN OR A MIXTURE ON BARE GROUND
IF(TEMPMIN - BASTEMF) 90,30,30
C-----IT IS ALL RAIN, DO NOT START BUILDING UP THE SNOWPACK
30 SNOMELT = PRECIP
GO TO 120
C-----A SNOWPACK EXISTS. IF THERE IS PRECIPITATION, DETERMINE THE TYPE.
C-----BUT OTHERWISE, JUST GO ON TO COMPUTE THE REFLECTIVITY AND
C-----RADIATION BALANCE
40 IF(PRECIP) 110,110,50
C-----THERE IS PRECIPITATION ON AN EXISTING PACK. IF IT IS NOT ALL
C-----SNOW, GO SEE IF ANY OF IT WAS SNOW
50 IF(TEMPMIN.GT.THIRTY2.AND.TEMPMAX.GT.BASTEMF) GO TO 70
60 CALL SNOWEO (AMIN1 (AVETEMC,D.0),PRECIP)
GO TO 110
C-----SEE WHETHER THE PRECIPITATION ON AN EXISTING PACK WAS ALL RAIN OR
C-----A MIXTURE OF RAIN AND SNOW
70 IF(TEMPMIN - BASTEMF) 90,80,80
C-----THIS IS A RAIN ON SNOW EVENT. THE TEMPERATURE FOR COMPUTING THE
C-----DEPLETION OF THE TOTAL CALORIC DEFICIT IS THE DIFFERENCE OF THE
C-----AVERAGE TEMPERATURE AND FREEZING (D.0 DEGREES CENTIGRADE)
80 CALL RAINEO (AVETEMC,PRECIP)
GO TO 100
C-----THIS IS A MIXTURE OF RAIN AND SNOW EVENT
90 CALL MIXTURE
C-----IF THE PACK WAS ENTIRELY MELTED, BYPASS COMPUTATION OF THE
C-----REFLECTIVITY AND THE RADIATION BALANCE
100 IF(PREWEQV) 120,120,110
C-----GET THE REFLECTIVITY FOR THIS INTERVAL
110 CALL GETREF
C-----COMPUTE THE RADIATION BALANCE AND ITS EFFECT ON THE PACK
CALL RAOBAL
RETURN
C-----THERE IS NO SNOWPACK - REDEFINE THE RADIATION BALANCE TO A
C-----NEGATIVE VALUE TO ASSURE THE PROPER SELECTION OF THE REFLECTIVITY
C-----FUNCTION IN SUBROUTINE GETREF WHEN THERE IS A SNOWPACK
120 CALORIE = -I.0
RETURN
ENO

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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
COMMON ACTOATE,ACTUAL(21),AVETEMC,AVETEMF
COMMON BASTEMF
COMMON CALAIR,CALDEF,CALORIE,CALSNOW,COVOEN
COMMON OATE,OATES(3),DEN,DENSITY,DREADY
COMMON ENGBAL
COMMON FOOTNOT(16),FREEWAT
COMMON HOLOCAP
COMMON IDATE(372),ISNOW,ITABLE
COMMON KOUNT
COMMON LASTUSD,LINES
COMMON NEXTACT
COMMON OBSWEQV
COMMON PACKTEM,PARTICE,PASTINT,PLOTDBS,PLOTWE,PRECIP,PREWEQV
COMMON RADIN,RADLWN,RAOSWN,REFLECT
COMMON SIMTEM1(3),SIMTEM2,SIMTEM3,SNOMELT,SOBSEQV(372),
1 SPRECIP(372),SPREQV(372),SUBTITL(8)
CDMMON TCDEFF,TEMPMAX,TEMPMIN,THRSHLD,TITLE(8),TOTPREC
CDMMON USEMEAN
CDMMON XMAX
INTEGER ACTOATE
INTEGER DATE,OATES,DREADY
INTEGER FOOTNOT
INTEGER PASTINT,PLOTDBS,PLOTWE
INTEGER SUBTITL
INTEGER TITLE

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INTEGER USEMEAN
C-----ADD THESE CALORIES INTO THE ENERGY BALANCE
ENGBAL = ENGBAL + CALORIN
C-----SEE IF A CALORIE DEFICIT EXISTS IN THE PACK
COMPARE = CALORIN - CALDEF
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 CALDEF = - COMPARE
C-----I.27 = D.05 * 2.54
PACKTEM = COMPARE/(PREWEQV*1.27)
RETURN
C-----THE CALORIE DEFICIT WAS WIPED OUT, BUT ALL OTHER CONDITIONS ARE
C-----UNCHANGED
20 CALDEF = D.0
PACKTEM = D.0
RETURN
C-----ANY DEFICIT WHICH DID EXIST WAS WIPED OUT. COMPUTE THE POTENTIAL
C-----MELT FROM THE REMAINING CALORIES (CALORIES/(BD.0 * 2.54))
30 PDTMELT = COMPARE/203.2
CALDEF = D.0
PACKTEM = D.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(PDTMELT.LT.PARTICE) GO TO 40
SNOMELT = SNOMELT + PREWEQV
PREWEQV = D.0
PARTICE = 0.0
FREEWAT = D.0
HOLOCAP = D.0
RETURN
C-----DELETE THE ICE PACK BY THE AMOUNT MELTED AND CONTRIBUTE THAT
C-----AMOUNT TO THE FREE WATER
40 PARTICE = PARTICE - PDTMELT
FREEWAT = FREEWAT + PDTMELT
C-----COMPUTE THE NEW HOLDING CAPACITY OF THE PACK AND COMPARE IT WITH
C-----THE FREE WATER TO SEE IF SNOWMELT IS PRODUCED
HOLOCAP = D.04 * PARTICE
COMPARE = FREEWAT - HOLOCAP
IF(COMPARE.LE.0.0) RETURN
C-----THE SNOWMELT CONTRIBUTED IS IN -COMPARE-- REDUCE THE FREE WATER
C-----TO LEAVE AT PRIMEO PACK AND REDUCE THE PREDICTED WATER EQUIVALENT
PREWEQV = PREWEQV - COMPARE
SNOMELT = SNOMELT + COMPARE
FREEWAT = HOLOCAP
RETURN
ENO

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Subroutine CALOSS

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SUBROUTINE CALOSS (CALOUT)
C-----THIS SUBROUTINE COMPUTES THE EFFECTS OF THE CALORIC LOSS ON THE
C-----SNOWPACK
COMMON ACTOATE,ACTUAL(21),AVETEMC,AVETEMF
COMMON BASTEMF
COMMON CALAIR,CALDEF,CALORIE,CALSNOW,COVOEN
COMMON OATE,OATES(3),DEN,DENSITY,DREADY
COMMON ENGBAL
COMMON FOOTNOT(16),FREEWAT
COMMON HOLOCAP
COMMON IDATE(372),ISNOW,ITABLE
COMMON KOUNT
COMMON LASTUSD,LINES
COMMON NEXTACT
COMMON OBSWEQV
COMMON PACKTEM,PARTICE,PASTINT,PLOTDBS,PLOTWE,PRECIP,PREWEQV
COMMON RADIN,RADLWN,RAOSWN,REFLECT
COMMON SIMTEM1(3),SIMTEM2,SIMTEM3,SNOMELT,SOBSEQV(372),
1 SPRECIP(372),SPREQV(372),SUBTITL(8)
CDMMON TCDEFF,TEMPMAX,TEMPMIN,THRSHLD,TITLE(8),TOTPREC
CDMMON USEMEAN
CDMMON XMAX
INTEGER ACTOATE
INTEGER DATE,OATES,DREADY
INTEGER FOOTNOT
INTEGER PASTINT,PLOTDBS,PLOTWE
INTEGER SUBTITL
INTEGER TITLE
INTEGER USEMEAN
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.D.0) GO TO 10
CALDEF = CALDEF - CALOUT
GO TO 50
C-----COMPUTE THE CALORIC LOSS NECESSARY TO FREEZE ALL OF THE FREE WATER
C-----IF (FREE WATER * BD.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 WIPED 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 WIPED OUT
20 CALDEF = - COMPARE
30 PARTICE = PARTICE + FREEWAT
FREEWAT = 0.0
GO TO 50
C-----ONLY PART OF THE FREE WATER FROZE. COMPUTE THE BALANCE REMAINING
C-----BALANCE = EXISTING FREE WATER - AMOUNT FROZEN, WHERE
C-----AMOUNT FROZEN = CALORIES/(BD.0 * 2.54)
40 FROZEN = - CALOUT/203.2

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PARTICE = PARTICE + FROZEN
FREEWAT = FREEWAT - FROZEN
RETURN
C-----COMPUTE THE NEW PACK TEMPERATURE AND HOLD CAPACITY
50 PACKTEM = -CALOEFF/(PREWEQV*1.27)
HOLCAP = 0.04 * PARTICE
RETURN
END

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Subroutine DIFMOD

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SUBROUTINE DIFMOD
C-----THIS SUBROUTINE WAS DERIVED FROM PROGRAM SIMTEM, A SNOWPACK
C-----TEMPERATURE DIFFUSION MODEL DEVELOPED BY LEAF (1970 STUDY PLAN
C-----FS-RH-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 ACTOATE,ACTUAL(21),AVETEMC,AVETEMF
COMMON BASTEMF
COMMON CALAIR,CALOEFF,CALORIE,CALSNOW,COVDEN
COMMON OATE,OATES(3),OEN,DENSITY,OREAOY
COMMON ENGBAL
COMMON FOOTNOT(16),FREEWAT
COMMON HOLCAP
COMMON IOATE(372),ISNOW,ITABLE
COMMON KOUNT
COMMON LASTUSO,LINES
COMMON NEXTACT
COMMON OBSWEQV
COMMON PACKTEM,PARTICE,PASTINT,PLOTOBS,PLOTWE,PRECIP,PREWEQV
COMMON RAOIN,RAOLWN,RAOSWN,REFLECT
COMMON SIMTEM1(3),SIMTEM2,SIMTEM3,SNOMELT,SOBSEQV(372),
1 SPRECIP(372),SPREQV(372),SUBTITL(8)
COMMON TCDEFF,TEMPMAX,TEMPMIN,THRSHLD,TITLE(8),TOTPREC
COMMON USEMEAN
COMMON XMAX
INTEGER ACTOATE
INTEGER OATE,OATES,OREAOY
INTEGER FOOTNOT
INTEGER PASTINT,PLOTOBS,PLOTWE
INTEGER SUBTITL
INTEGER TITLE
INTEGER USEMEAN
C-----
C-----DICTIONARY
C
C CALOM - THE CALORIC INPUT OR LOSS AS DERIVED BY THE DIFFUSION
C MODEL
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-----
COMMON/CONVERT/FIVE9TH,THIRTY2
C-----IF THIS IS THE DATE OF THE ACTUAL OR OBSERVED PACK TEMPERATURES,
C-----BYPASS THE SIMULATION AND USE THE OBSERVED AVERAGE
IF(OATE - ACTOATE) 10,100,10
C-----IF THE DENSITY WAS NOT SPECIFIED ON THE INPUT CARD, COMPUTE IT AS
C-----A FUNCTION OF THE WATER EQUIVALENT. (THE FUNCTION WAS DERIVED
C-----FROM OBSERVED CONDITIONS ON THE FRASER EXPERIMENTAL FOREST)
10 IF(OEN) 20,20,30
20 DENSITY = (EXP((O.D179 * PREWEQV) + 3.02))/100.0
GO TO 40
30 DENSITY = OEN
C-----COMPUTE THE DISTANCE BETWEEN THE TWO NODES IN CENTIMETERS
C-----DEPTH = PREWEQV/DENSITY
C-----H = (DEPTH/2)*2.54
40 H = (PREWEQV/DENSITY) * 1.27
C-----THE THERMAL DIFFUSIVITY IS CALCULATED FROM THE FUNCTION
KV = 0.01/((2.751 - DENSITY)* 0.48). MATHEMATICAL STABILITY
C-----REQUIRES THAT THE VALUE OF THE QUANTITY (INTERVAL IN SECONDS *
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)
CONST1 = (43200 * 0.01/((2.751 - DENSITY) * 0.48))/H**2
CONST1 = 900.0/((2.751 - DENSITY)*H**4)
C-----THE MINIMUM WATER EQUIVALENT WHICH WILL ACHIEVE STABILITY USING
C-----THE ABOVE DENSITY FUNCTION IS 4.7 INCHES
IF(CONST1 - 0.5) 60,50,50
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 CARD
C-----AND STABILITY WILL BE ASCERTAINED FROM THE WATER EQUIVALENT AT
C-----THAT TIME)
50 OREAOY = 0
RETURN
C-----GET THE SECOND CONSTANT
60 CONST2 = 1.0 - CONST1 - CONST1
C-----PERFORM THE SIMULATION IN TWO PARTS (ONE FOR EACH 12 HOUR PERIOD).
C-----SIMTEM1- HOLDS THE THREE TEMPERATURES FROM THE PREVIOUS INTERVAL
C-----THAT ARE NEEDED TO SIMULATE SIMTEM2, THE NODE 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----- (MIDDLE 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

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SIMTEM1(1) = AMIN1 (0.0,(((TEMPMIN-THIRTY2)*FIVE9TH)+AVETEMC)/2.0)
SIMTEM1(2) = SIMTEM2
C-----SIMULATE THE SECOND 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,(((TEMPMAX-THIRTY2)*FIVE9TH)+AVETEMC)/2.0)
SIMTEM1(2) = SIMTEM2
C-----CHECK TO SEE IF THE GROUND TEMPERATURE SHOULD BE RAISED
IF(SIMTEM3 + 1.5) 100,80,70
70 IF(SIMTEM3 + 0.5) 80,90,90
80 IF(SIMTEM1(3).LT.-0.5) SIMTEM1(3) = -0.5
RETURN
90 SIMTEM1(3) = D.0
100 RETURN
END

```

Subroutine GETREF

```

SUBROUTINE GETREF
C-----GET THE REFLECTIVITY
C-----
C-----DICTIONARY
C
REFACUM - A REFLECTIVITY FUNCTION FOR THE SNOWPACK DURING THE
C ACCUMULATION PHASE OF THE SNOWPACK
C REFMELT - A REFLECTIVITY FUNCTION FOR THE SNOWPACK DURING THE
C MELT PHASE OF THE SNOWPACK
C-----
COMMON ACTOATE,ACTUAL(21),AVETEMC,AVETEMF
COMMON BASTEMF
COMMON CALAIR,CALOEFF,CALORIE,CALSNOW,COVDEN
COMMON OATE,OATES(3),OEN,DENSITY,OREAOY
COMMON ENGBAL
COMMON FOOTNOT(16),FREEWAT
COMMON HOLCAP
COMMON IOATE(372),ISNOW,ITABLE
COMMON KOUNT
COMMON LASTUSO,LINES
COMMON NEXTACT
COMMON OBSWEQV
COMMON PACKTEM,PARTICE,PASTINT,PLOTOBS,PLOTWE,PRECIP,PREWEQV
COMMON RAOIN,RAOLWN,RAOSWN,REFLECT
COMMON SIMTEM1(3),SIMTEM2,SIMTEM3,SNOMELT,SOBSEQV(372),
1 SPRECIP(372),SPREQV(372),SUBTITL(8)
COMMON TCDEFF,TEMPMAX,TEMPMIN,THRSHLD,TITLE(8),TOTPREC
COMMON USEMEAN
COMMON XMAX
INTEGER ACTOATE
INTEGER OATE,OATES,OREAOY
INTEGER FOOTNOT
INTEGER PASTINT,PLOTOBS,PLOTWE
INTEGER SUBTITL
INTEGER TITLE
INTEGER USEMEAN
DIMENSION REFACUM(15),REFMELT(15)
DATA REFACUM/.BD, .77, .75, .72, .70, .69, .68, .67, .66, .65,
1 .64, .63, .62, .61, .60/
DATA REFMELT/.72, .65, .60, .58, .56, .54, .52, .50, .48, .46,
1 .44, .43, .42, .41, .40/
C-----INCREASE THE INTERVAL COUNTER BY 1 AND SEE IF THERE WAS ANY SNOW
PASTINT = PASTINT + 1
IF(ISNOW) 10,10,80
C-----USE THE SAME FUNCTION AS LAST TIME
10 IF(LASTUSO) 20,20,50
C-----ACCUMULATION PHASE - AFTER 15 DAYS, USE THE MELT FUNCTION
C-----STARTING AT THE FOURTH DAY
20 IF(PASTINT - 15) 30,30,40
30 REFLECT = REFACUM(PASTINT)
RETURN
40 PASTINT = 4
LASTUSO = 1
GO TO 70
C-----MELT FUNCTION - AFTER 15 DAYS, USE A CONSTANT 40 PERCENT
50 IF(PASTINT - 15) 70,70,60
60 PASTINT = 15
70 REFLECT = REFMELT(PASTINT)
RETURN
C-----THERE IS NEW SNOW - DETERMINE IF THE FUNCTION IS TO BE RE-
C-----INITIALIZED
80 IF(TEMPMAX - THRSHLD) 90,90,10
C-----IT IS, SO SEE WHICH FUNCTION IS TO BE USED
90 PASTINT = 0
IF(PACKTEM) 100,110,110
100 REFLECT = 0.91
LASTUSO = 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
110 IF(CALORIE) 100,120,120
120 REFLECT = 0.81
LASTUSO = 1
RETURN
END

```

Subroutine INITIAL

```

SUBROUTINE INITIAL
C-----READ THE PARAMETERS AND INITIALIZE THE MELT MODEL

```



```

COMMON ACTOATE,ACTUAL(21),AVETEMC,AVETEMF
COMMON BASTEMF
COMMON CALAIR,CALDEF,CALORIE,CALSNOW,COVOEN
COMMON OATE,OATES(3),OEN,OENSITY,OREADY
COMMON ENGBAL
COMMON FOOTNOT(16),FREEWAT
COMMON HOLOCAP
COMMON IOATE(372),ISNOW,ITABLE
COMMON KOUNT
COMMON LASTUSO,LINES
COMMON NEXTACT
COMMON OBSWEQV
COMMON PACKTEM,PARTICE,PASTINT,PLOTBS,PLOTWE,PRECIP,PREWEQV
COMMON RAOIN,RAOLWN,RAOSWN,REFLECT
COMMON SIMTEM1(3),SIMTEM2,SIMTEM3,SNOMELT,SQBSEQV(372),
1 SPRECIP(372),SPREQV(372),SUBTITL(8)
COMMON TCOEFF,TEMPMAX,TEMPMIN,THRSLO,TITLE(8),TOTPREC
COMMON USEMEAN
COMMON XMAX
INTEGER ACTOATE
INTEGER OATE,OATES,OREADY
INTEGER FOOTNOT
INTEGER PASTINT,PLOTBS,PLOTWE
INTEGER SUBTITL
INTEGER TITLE
INTEGER USEMEAN
C-----ESTABLISH THE STANDARD BASE TEMPERATURE
BASTEMF = 35.0
C-----INITIALIZE THOSE VARIABLES WHICH ARE NOT READ IN OR OTHERWISE
C-----INITIALIZED BEFORE BEING USED
FREEWAT = 0.0
HOLOCAP = 0.0
SUM = 0.0
TOTAL = 0.0
XMAX = 0.0
OREADY = 0
ISNOW = 0
KOUNT = 0
LASTUSO = 0
PASTINT = 0
LINES = 999
C-----START THE RADIATION BALANCE WITH A NEGATIVE VALUE FOR POSSIBLE USE
C-----BY SUBROUTINE GETREF IN DETERMINING WHICH REFLECTIVITY FUNCTION
C-----TO USE
CALORIE = -1.0
C-----READ THE INSTRUCTION PARAMETERS AND THE CONTROLS ON THE MODEL
READ (5,910) ITABLE,PLOTWE,PLOTBS,USEMEAN,TCOEFF,COVOEN,PACKTEM,
1 PREWEQV,THRSLO
910 FORMAT(4I1,1X,5F5.2)
IF(EOF(5)) 10,10,20
C-----READ THE TITLE, SUBTITLE AND FOOTNOTE CARDS
10 READ (5,920) TITLE,SUBTITL,FOOTNOT
920 FORMAT(BA10)
C-----INITIALIZE THE ICE CONTENT AND ACCUMULATED PRECIPITATION
PARTICE = PREWEQV
TOTPREC = PREWEQV
C-----CALCULATE THE CALORIE DEFICIT FROM THE PACK TEMPERATURE
C-----CALDEF = - (PACKTEM * 80) * (PREWEQV * 2.54) / 160
CALDEF = - PACKTEM * PREWEQV * 1.27
RETURN
20 STOP
END

```

Subroutine LINK

```

SUBROUTINE LINK (IRETURN)
C-----THIS SUBROUTINE IS THE INTERFACE BETWEEN THE RADIATION BALANCE
C----- (SUBROUTINE RAOBAL) AND THE DIFFUSION MODEL (SUBROUTINE OIFMOD)
COMMON ACTOATE,ACTUAL(21),AVETEMC,AVETEMF
COMMON BASTEMF
COMMON CALAIR,CALDEF,CALORIE,CALSNOW,COVOEN
COMMON OATE,OATES(3),OEN,OENSITY,OREADY
COMMON ENGBAL
COMMON FOOTNOT(16),FREEWAT
COMMON HOLOCAP
COMMON IOATE(372),ISNOW,ITABLE
COMMON KOUNT
COMMON LASTUSO,LINES
COMMON NEXTACT
COMMON OBSWEQV
COMMON PACKTEM,PARTICE,PASTINT,PLOTBS,PLOTWE,PRECIP,PREWEQV
COMMON RAOIN,RAOLWN,RAOSWN,REFLECT
COMMON SIMTEM1(3),SIMTEM2,SIMTEM3,SNOMELT,SQBSEQV(372),
1 SPRECIP(372),SPREQV(372),SUBTITL(8)
COMMON TCOEFF,TEMPMAX,TEMPMIN,THRSLO,TITLE(8),TOTPREC
COMMON USEMEAN
COMMON XMAX
INTEGER ACTOATE
INTEGER OATE,OATES,OREADY
INTEGER FOOTNOT
INTEGER PASTINT,PLOTBS,PLOTWE
INTEGER SUBTITL
INTEGER TITLE
INTEGER USEMEAN
COMMON/CONVERT/FIVE9TH,THIRTY2
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 FREEWATER), JUST
C-----GO AHEAD AND USE THE DIFFUSION MODEL
10 IF(FREEWAT) 20,20,50
C-----USE THE DIFFUSION MODEL TO SIMULATE THE CURRENT AVERAGE SNOWPACK
C-----TEMPERATURE
20 CALL OIFMOD
IF(OREADY) 40,40,30

```

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C-----NOW MAKE ANY NECESSARY ADJUSTMENTS IN THE RADIATION BALANCE TO
C-----CAUSE THE PACK TEMPERATURE TO BE THE SAME AS -SIMTEM3-. START BY
C-----GETTING THE DIFFERENCE BETWEEN THE LAST PACK TEMPERATURE AND THIS
C-----ONE, THEN CONVERT IT TO CALORIES
30 CALOM = (SIMTEM3 - PACKTEM) * 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
RAOLWN = RAOLWN + (CALOM - CALORIE)
CALORIE = CALOM
40 IRETURN = 0
RETURN
C-----THE LOSS IS USED TO FREEZE PART OR ALL OF THE FREE WATER, BUT IT
C-----MAY NOT CREATE COLD CONTENT. IF IT WOULD CREATE COLD CONTENT,
C-----RE-INITIALIZE THE DIFFUSION MODEL TO 0 AND ADJUST THE ENERGY
C-----BALANCE ACCORDINGLY
50 CALL CALOSS (CALORIE)
IF(FREEWAT - 0.5) 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 COLD CONTENT THAT WOULD HAVE BEEN GENERATED BY THIS LOSS
C-----AND ZERO THE COLD CONTENT
CALORIE = CALORIE + CALDEF
RAOLWN = RAOLWN + CALDEF
PARTICE = PARTICE + FREEWAT
PREWEQV = PREWEQV + FREEWAT
FREEWAT = 0.0
CALDEF = 0.0
PACKTEM = 0.0
70 IRETURN = 1
RETURN
C-----THERE IS CALORIC INPUT TO THE PACK. CHECK TO SEE IF CONDITIONS
C-----INDICATE THAT THE DIFFUSION MODEL SHOULD BE TURNED OFF AND THE
C-----ENERGY BALANCE USED FOR SPRINGTIME SIMULATION. CONSIDER FIRST
C-----ANY COLD CONTENT (INCLUDING THAT OF THE PREVIOUS DAY AND ANY
C-----CREATED BY A SNOW EVENT ON THIS DAY). IF THERE IS COLD CONTENT,
C-----CHECK THE AVERAGE AIR TEMPERATURE AND THE SNOWPACK TEMPERATURE
C-----FROM THE PREVIOUS DAY FOR ARBITRARILY CHOSEN SPRINGTIME CONDITIONS
C-----AND IF ALL ARE NOT SATISFIED, GO AHEAD AND USE THE DIFFUSION
C-----MODEL
80 IF(CALDEF) 170,170,90
90 IF(AVETEMC.LE.0.0.OR.PACKTEM.LE.-0.7) GO TO 20
C-----SINCE SPRINGTIME CONDITIONS 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(ISNOW) 100,100,140
100 USE = (TEMPMIN - THIRTY2) * FIVE9TH
IF(USE.GT.0.0) USE = 0.0
CALSNOW = 1.17E-7 * ((USE + 273.16) ** 4)
IF(PRECIP) 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 = RAOSWN + RAOLWN
C-----RE-INITIALIZE THE DIFFUSION MODEL TO THESE CONDITIONS (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 CONSECU-
C-----TIVE DAYS OF INPUT ARE REQUIRED TO GENERATE FREE WATER)
140 ACTOATE = OATE
COMPARE = CALORIE - CALDEF
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
GO TO 20
C-----REDEFINE THE SURFACE TEMPERATURE AND COMPUTE THE NEW AVERAGE PACK
C-----TEMPERATURE. THEN COMPUTE THE MIDDLE NODE AS A FUNCTION OF THAT
C-----AVERAGE, THE SURFACE TEMPERATURE AND THE GROUND TEMPERATURE
C----- (WHICH REMAINED UNCHANGED)
160 SIMTEM1(1) = AMIN1 (0.0,AVETEMC)
SIMTEM3 = COMPARE/(PREWEQV * 1.27)
SIMTEM1(2) = (3.0 * SIMTEM3) - SIMTEM1(1) - SIMTEM1(3)
SIMTEM1(3) = 0.0
GO TO 20
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, TURN THE DIFFUSION MODEL OFF AND LET THE ENERGY
C-----BALANCE TAKE ITS COURSE
170 IF(FREEWAT + (CALORIE/203.2) - 0.05) 150,180,180
180 OREADY = 0
IRETURN = 0
RETURN
END

```

Subroutine MIXTURE

```

SUBROUTINE MIXTURE
C-----THIS SUBROUTINE CONTROLS THE COMPUTATIONS FOR A PRECIPITATION
C-----EVENT THAT IS A MIXTURE OF SNOW AND RAIN
C-----
C-----DICTIONARY
C-----
AMTSNOW - THE AMOUNT OF PRECIPITATION OCCURRING AS SNOW (INCHES)
TFORAIN - THE TEMPERATURE FOR COMPUTING THE DEPLETION OF THE TOTAL
CALORIE DEFICIT CAUSED BY THE RAIN (DEGREES C)
TFORSNO - THE TEMPERATURE FOR COMPUTING THE CONTRIBUTION OF THE
SNOW TO THE TOTAL CALORIE DEFICIT (DEGREES C)

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C-----DICTIONARY
C   AMTRAIN - THE AMOUNT OF PRECIPITATION OCCURRING AS RAIN (INCHES)
C   CALRAIN - THE DEPLETION OF THE TOTAL CALORIE DEFICIT BY THIS RAIN
C             (CALDRIES)
C   TFDRAIN - THE TEMPERATURE FOR COMPUTING THE DEPLETION OF THE TOTAL
C             CALORIE DEFICIT CAUSED BY THIS RAIN (DEGREES C)
C-----
COMMON ACTDATE,ACTUAL(21),AVETEMC,AVETEMF
COMMON BASTEMF
COMMON CALAIR,CALDEF,CALDRIE,CALSNDW,CDVDEN
COMMON DATE,DATES(3),DEN,DENSITY,DREADY
COMMON ENGBAL
COMMON FDDTNDT(16),FREEWAT
COMMON HDLDCAP
COMMON IDATE(372),ISNDW,ITABLE
COMMON KOUNT
COMMON LASTUSD,LINES
COMMON NEXTACT
COMMON DBSWEQV
COMMON PACKTEM,PARTICE,PASTINT,PLDTDBS,PLDTWE,PRECIP,PREWEQV
COMMON RADIN,RADLWN,RADSWN,REFLECT
COMMON SIMTEM1(3),SIMTEM2,SIMTEM3,SNDMELT,SDBSEQV(372),
1   SPRECIP(372),SPREQV(372),SUBTITL(B)
COMMON TCDEFF,TEMPMAX,TEMPMIN,THRSHLD,TITLE(B),TDTPREC
COMMON USEMEAN
COMMON XMAX
INTEGER ACTDATE
INTEGER DATE,DATES,DREADY
INTEGER FDDTNDT
INTEGER PASTINT,PLDTDBS,PLDTWE
INTEGER SUBTITL
INTEGER TITLE
INTEGER USEMEAN
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
IF(CALDEF.LE.D.D) GO TO 5D
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
AMTNEED = CALDEF/((BD.D + TFDRAIN) * 2.54)
COMPARE = AMTRAIN - AMTNEED
IF(COMPARE) 2D,1D,4D
C-----THERE WAS JUST ENOUGH TO WIPE OUT THE DEFICIT
1D CALDEF = D.D
PACKTEM = D.D
GO TO 3D
C-----THERE WAS NOT ENOUGH TO WIPE IT OUT COMPLETELY. JUST DEplete
C-----THE DEFICIT
2D CALDEF = CALDEF - ((BD.D + TFDRAIN) * AMTRAIN * 2.54)
PACKTEM = -CALDEF/(PREWEQV*1.27)
C-----ADD ALL THE RAIN TO THE PACK AS ICE AND GET THE NEW HOLDING
C-----CAPACITY
3D PARTICE = PARTICE + AMTRAIN
HDLDCAP = D.D4 * PARTICE
RETURN
C-----THERE WAS MORE THAN ENOUGH TO WIPE OUT THE DEFICIT. ADD THE
C-----FROZEN PART TO THE ICE AND GET THE NEW HOLDING CAPACITY
4D CALDEF = D.D
PACKTEM = D.D
PARTICE = PARTICE + AMTNEED
HDLDCAP = D.D4 * PARTICE
C-----THE AMOUNT OF RAIN NOT FROZEN IS FREE WATER AND CONTRIBUTES
C-----CALDRIC INPUT TO THE PACK
FREEWAT = COMPARE
CALL CALIN (TFDRAIN * COMPARE * 2.54)
RETURN
C-----ALL OF THE RAIN IS ADDED TO THE FREE WATER AND CONTRIBUTES CALDRIC
C-----INPUT TO THE PACK
5D FREEWAT = FREEWAT + AMTRAIN
CALL CALIN (TFDRAIN * AMTRAIN * 2.54)
RETURN
END

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Subroutine RDPACK

```

SUBROUTINE ROPACK
C-----THIS SUBROUTINE READS THE ACTUAL OR OBSERVED SNOWPACK TEMPERATURE
C-----CARD AND INITIALIZES THE DIFFUSION MODEL (SUBROUTINE DIFMDD). IT
C-----IS CALLED WHENEVER CDL 7D OF AN INPUT CARD IS NOT BLANK OR ZERO
COMMON ACTDATE,ACTUAL(21),AVETEMC,AVETEMF
COMMON BASTEMF
COMMON CALAIR,CALDEF,CALDRIE,CALSNDW,CDVDEN
COMMON DATE,DATES(3),DEN,DENSITY,DREADY
COMMON ENGBAL
COMMON FDDTNDT(16),FREEWAT
COMMON HDLDCAP
COMMON IDATE(372),ISNDW,ITABLE
COMMON KOUNT
COMMON LASTUSD,LINES
COMMON NEXTACT
COMMON DBSWEQV
COMMON PACKTEM,PARTICE,PASTINT,PLDTDBS,PLDTWE,PRECIP,PREWEQV
COMMON RADIN,RADLWN,RADSWN,REFLECT
COMMON SIMTEM1(3),SIMTEM2,SIMTEM3,SNDMELT,SDBSEQV(372),
1   SPRECIP(372),SPREQV(372),SUBTITL(B)
COMMON TCDEFF,TEMPMAX,TEMPMIN,THRSHLD,TITLE(B),TDTPREC
COMMON USEMEAN
COMMON XMAX
INTEGER ACTDATE
INTEGER DATE,DATES,DREADY
INTEGER FDDTNDT
INTEGER PASTINT,PLDTDBS,PLDTWE
INTEGER SUBTITL
INTEGER TITLE

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```

INTEGER USEMEAN
READ (5,91D) I,ACTDATE,ACTUAL
91D FORMAT(I,D,1X16,21F3.1)
C-----BE SURE THIS IS AN OBSERVED PACK TEMPERATURE CARD AND THAT THE
C-----DATE IS THE SAME AS THE CARD JUST READ BY SUBROUTINE READER. IF
C-----NOT, ABORT THE JOB
IF(I.EQ.1D)DBS PACK T) GO TO 2D
1D PRINT 92D,DATE,NEXTACT
92D FORMAT(10I10,1X16,21F3.1)
1 TEMPERATURE CARD WAS NEXT (CDL 7D CONTAINED A*12,*,* /DBUT EITHE
2R COLUMNS 1 - 1D OF THE NEXT CARD DO NOT CONTAIN -DBS PACK T- DR T
3HE DATES ARE NOT THE SAME)
CALL SYSTEM (999,12H-JOB ABORTED)
2D IF(DATE - ACTDATE) 1D,3D,1D
C-----GET THE ACTUAL AVERAGE SNOWPACK TEMPERATURE (THE TEMPERATURES READ
C-----IN ARE ALL POSITIVE - THE NEGATIVES WILL BE INSERTED BY THIS
C-----SUBROUTINE)
3D DUMMY1 = 1.D
DUMMY2 = ACTUAL(2D)
DD 6D I = 1,19
C-----WATCH FOR BLANKS TO PREVENT AVERAGING ZERDES (A BLANK IS READ AS A
C-----NEGATIVE ZERO, WHICH MAY BE DETECTED BY THE FOLLOWING TWO TESTS)
IF(ACTUAL(I)) 5D,4D,5D
4D IF(SIGN(1.D,ACTUAL(I))) 7D,7D,5D
5D DUMMY1 = DUMMY1 + 1.D
6D DUMMY2 = DUMMY2 + ACTUAL(I)
C-----COMPUTE THE AVERAGE
7D SIMTEM3 = - DUMMY2/DUMMY1
C-----FILL IN -SIMTEM1- WITH THE OBSERVED TEMPERATURES. START WITH THE
C-----AVERAGE AIR TEMPERATURE
SIMTEM1(1) = AMIN1 (AVETEMC,D.D)
C-----GROUND TEMPERATURE
SIMTEM1(3) = - ACTUAL(2D)
C-----FIND THE MEDIAN DEPTH OF THE PACK FROM THE WATER EQUIVALENT
WEQV = PREWEQV + PRECIP
C-----IF THE DENSITY WAS NOT SPECIFIED ON THE INPUT CARD, COMPUTE IT AS
C-----A FUNCTION OF THE WATER EQUIVALENT. (THE FUNCTION WAS DERIVED
C-----FROM 1969 OBSERVED CONDITIONS ON THE FRASER EXPERIMENTAL FOREST)
IF(DEN) 9D,9D,8D
8D DENSITY = DEN
GO TO 1DD
9D DENSITY = (EXP((D.D179 * WEQV) + 3.02))/1DD.D
C-----DEPTH = WEQV/DENSITY
C-----MEDIAN = DEPTH/2
1DD DUMMY1 = WEQV/(DENSITY + DENSITY)
C-----INTERPOLATE BETWEEN THE ACTUAL TEMPERATURES ON EITHER SIDE OF THIS
C-----DEPTH TO OBTAIN THE TEMPERATURE. (THE SUBSCRIPT OF THE TEMP
C-----ABOVE IT IS FOUND BY TRUNCATING THE QUOTIENT OF THIS DEPTH
C-----DIVIDED BY THE DISTANCE BETWEEN MEASUREMENTS. THE INTERPOLATION
C-----IS LINEAR)
SUBSCRIP = DUMMY1/ACTUAL(21)
I = SUBSCRIP
TRUNCAT = I
SIMTEM1(2) = - ACTUAL(I) - ((ACTUAL(I) - ACTUAL(I+1)) * (TRUNCAT -
1 SUBSCRIP))
C-----INDICATE THAT THE DIFFUSION MODEL HAS BEEN INITIALIZED AND IS
C-----READY FOR USE
DREADY = 1
RETURN
END

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Subroutine READER

```

SUBROUTINE READER (IEND)
C-----THIS SUBROUTINE READS A DATA CARD AND COMPUTES THE AVERAGE
C-----TEMPERATURES
COMMON ACTDATE,ACTUAL(21),AVETEMC,AVETEMF
COMMON BASTEMF
COMMON CALAIR,CALDEF,CALDRIE,CALSNDW,CDVDEN
COMMON DATE,DATES(3),DEN,DENSITY,DREADY
COMMON ENGBAL
COMMON FDDTNDT(16),FREEWAT
COMMON HDLDCAP
COMMON IDATE(372),ISNDW,ITABLE
COMMON KOUNT
COMMON LASTUSD,LINES
COMMON NEXTACT
COMMON DBSWEQV
COMMON PACKTEM,PARTICE,PASTINT,PLDTDBS,PLDTWE,PRECIP,PREWEQV
COMMON RADIN,RADLWN,RADSWN,REFLECT
COMMON SIMTEM1(3),SIMTEM2,SIMTEM3,SNDMELT,SDBSEQV(372),
1   SPRECIP(372),SPREQV(372),SUBTITL(B)
COMMON TCDEFF,TEMPMAX,TEMPMIN,THRSHLD,TITLE(B),TDTPREC
COMMON USEMEAN
COMMON XMAX
INTEGER ACTDATE
INTEGER DATE,DATES,DREADY
INTEGER FDDTNDT
INTEGER PASTINT,PLDTDBS,PLDTWE
INTEGER SUBTITL
INTEGER TITLE
INTEGER USEMEAN
COMMON/CONVERT/FIVE9TH,THIRTY2
C-----READ A CARD AND CHECK FOR THE END OF FILE
READ (5,9DD) DATES,RADIN,TEMPMAX,TEMPMIN,DBSWEQV,PRECIP,DEN,
1 NEXTACT
9DD FORMAT(3I2,F4.D,7X,2F4.1,14X3F5.2,15X11)
IF(EOF(5)) 2D,2D,1D
1D IEND = 1
RETURN
2D IEND = D
DATE = DATES(1)*1DDDD + DATES(2)*1DD + DATES(3)
IF(DATE) 7D,7D,3D
C-----COMPUTE THE MEAN TEMPERATURE IN FARENHEIT, THEN CONVERT IT TO

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C----- CENTIGRAOE
30 AVETEMF = (TEMPMAX + TEMPMIN) * 0.5
AVETEMC = (AVETEMF - THIRTY2) * FIVE9TH
IF(USEMEAN) 50,50,40
40 TEMPMAX = AVETEMF
TEMPMIN = AVETEMF
C-----SEE IF THE NEXT CARO IS AN ACTUAL PACK TEMPERATURE CARO
50 IF(NEXTACT) 70,70,60
60 CALL ROPACK
70 RETURN
ENO

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Subroutine SNOWED

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SUBROUTINE SNOWED (TFORSNO,AMTSNOW)
C-----THIS SUBROUTINE COMPUTES THE EFFECTS OF A SNOW EVENT ON THE
C----- SNOWPACK
C-----
C-----OICITIONARY
C
AMTSNOW - THE AMOUNT OF PRECIPITATION OCCURRING AS SNOW (INCHES)
CALSNOW - THE CONTRIBUTION OF THIS SNOW TO THE TOTAL CALORIE
DEFICIT (CALORIES)
TFORSNO - THE TEMPERATURE FOR COMPUTING THE CONTRIBUTION OF THIS
SNOW TO THE TOTAL CALORIE DEFICIT (DEGREES C)
C-----
COMMON ACTOATE,ACTUAL(21),AVETEMC,AVETEMF
COMMON BASTEMF
COMMON CALAIR,CALDEF,CALORIE,CALSNOW,COVOEN
COMMON OATE,OATES(3),OEN,DENSITY,OREADY
COMMON ENGBAL
COMMON FOOTNOT(16),FREEWAT
COMMON HOLOCAP
COMMON IOATE(372),ISNOW,ITABLE
COMMON KOUNT
COMMON LASTUSO,LINES
COMMON NEXTACT
COMMON OBSWEQV
COMMON PACKTEM,PARTICE,PASTINT,PLOTOBS,PLOTWE,PRECIP,PREWEQV
COMMON RADIN,RADLWN,RAOSWN,REFLECT
COMMON SIMTEM1(3),SIMTEM2,SIMTEM3,SNOMELT,SQBSEQV(372),
1 SPRECIP(372),SPREQV(372),SUBTITL(8)
COMMON TCOEFF,TEMPMAX,TEMPMIN,THRSHLO,TITLE(8),TOTPREC
COMMON USEMEAN
COMMON XMAX
INTEGER ACTOATE
INTEGER OATE,OATES,OREADY
INTEGER FOOTNOT
INTEGER PASTINT,PLOTOBS,PLOTWE
INTEGER SUBTITL
INTEGER TITLE
INTEGER USEMEAN
ISNOW = 1
C-----ADD THIS AMOUNT OF PRECIPITATION TO THE PREDICTED WATER EQUIVALENT
C----- AND GET THE NEW HOLOING CAPACITY
PREWEQV = PREWEQV + AMTSNOW
PARTICE = PARTICE + AMTSNOW
HOLOCAP = 0.04 * PARTICE
C-----THE SNOW FALLING WHEN THE TEMPERATURE IS BETWEEN 35 AND 32 DEGREES
C----- DOES NOT ALTER THE CALORIC DEFICIT
IF(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 CENTIGRAOE), 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 * 1.27)
RETURN
ENO

```

Subroutine STORE

```

SUBROUTINE STORE
C-----STORE THE INFORMATION NEEDED FOR THE PLOT
COMMON ACTOATE,ACTUAL(21),AVETEMC,AVETEMF
COMMON BASTEMF
COMMON CALAIR,CALDEF,CALORIE,CALSNOW,COVOEN
COMMON OATE,OATES(3),OEN,DENSITY,OREADY
COMMON ENGBAL
COMMON FOOTNOT(16),FREEWAT
COMMON HOLOCAP
COMMON IOATE(372),ISNOW,ITABLE
COMMON KOUNT
COMMON LASTUSO,LINES
COMMON NEXTACT
COMMON OBSWEQV
COMMON PACKTEM,PARTICE,PASTINT,PLOTOBS,PLOTWE,PRECIP,PREWEQV
COMMON RADIN,RADLWN,RAOSWN,REFLECT
COMMON SIMTEM1(3),SIMTEM2,SIMTEM3,SNOMELT,SQBSEQV(372),
1 SPRECIP(372),SPREQV(372),SUBTITL(8)
COMMON TCOEFF,TEMPMAX,TEMPMIN,THRSHLO,TITLE(8),TOTPREC
COMMON USEMEAN
COMMON XMAX
INTEGER ACTOATE
INTEGER OATE,OATES,OREADY
INTEGER FOOTNOT
INTEGER PASTINT,PLOTOBS,PLOTWE
INTEGER SUBTITL
INTEGER TITLE
INTEGER USEMEAN
C-----KEEP TRACK OF THE LARGEST VALUE FOR SCALING THE PLOT

```

```

XMAX = AMAX1 (XMAX,OBSWEQV,PREWEQV)
C-----INCREASE THE COUNTER
KOUNT = KOUNT + 1
IDATE(KOUNT) = OATE
SPRECIP(KOUNT) = PRECIP
SPREQV(KOUNT) = PREWEQV
IF(PLOTOBS) 10,10,20
C-----BY STORING A NUMBER OUTSIDE THE LIMITS OF THE PLOT, IT WILL BE
C----- IGNORED
10 SQBSEQV(KOUNT) = -1.0
RETURN
C-----THE OBSERVED WATER EQUIVALENT IS TO BE PLOTTED
20 SQBSEQV(KOUNT) = OBSWEQV
RETURN
ENO

```

Subroutine TSPLIT

```

SUBROUTINE TSPLIT(MX,X1,X2,X3,X4,X5,X6,XMAX,XMIN,IT,INT,INIT)
C-----THIS ROUTINE DOES THE ACTUAL PLOTTING
C. HWANG, A.C. HOGGATT 1 JULY, 1962
C
C ARGUMENTS
C MX=NUMBER OF VARIABLES TO BE PLOTTED, LESS THAN OR EQUAL TO 6
C X1=VALUE ATTACHED TO FIRST VARIABLE. PLOTTING SYMBOL WILL BE A 1.
C X2=VALUE ATTACHED TO SECOND VARIABLE. PLOTTING SYMBOL WILL BE A 2.
C X3
C .
C .
C X6 AND SO ON FOR XN
C XMAX=UPPER END OF ORIGINATE SCALE
C XMIN=LOWER END OF ORIGINATE SCALE
C IT=ABSCISSA VALUE. (I.E., T, FOR XT)
C INT=ABSCISSA LABELLING INTERVAL. (I.E., EVERY ICHTH LINE OF PLOT
C WILL BE LABELLED WITH VALUE OF IOY ON HORIZONTAL AXIS)
C INIT =INITIALIZING PARAMETER, USED AS FOLLOWS.
C INIT =1, GRAPH WILL COMPUTE AND PRINT ORIGINATE, PLOO
C AND PRINT FIRST LINE OF GRAPH. SUBSEQUENT CALL WILL PLOT AND PRNT
C A LINE OF GRAPH ONLY.
C INIT =-1 USED TO READY SUBROUTINE FOR PLOTTING NEW GRAPH.
C SUBROUTINE DOES NO PLOTTING OR PRINTING WITH THIS SETTING OF INIT.
C IF THE VALUE OF SCALING PARAMETERS XMIN AND/OR XMAX DIFFER FROM
C THE PREVIOUSLY GIVEN ONES WITHOUT RESETTING OF INIT, TS PLOT
C WILL RESET SCALE ACCORDING TO NEW XMIN AND/OR XMAX AND PRINT OUT
C NEW ORIGINATE POINT VALUES TO AGREE WITH SCALING OF PLOTTED POINTS
C INTERNAL VARIABLES
C CHARS CONTAINS 80 CHARACTERS USED AS PLOTTING SYMBOL.
C PLOT HOLDS THE HOLLERITH IMAGE FOR ONE LINE OF PLOT.
C XN. SCALAR ARGUMENTS ARE STORED IN THIS LINEAR ARRAY.
C DELTA IS A SCALING PARAMETER, EQUAL TO THE RANGE DIVIDED BY 110, AND
C IS RECOMPUTED WHEN NEW SCALE IS INDICATED (WHEN INIT =1 OR WHEN
C XMAX OR XMIN VALUE DIFFERING FROM PREVIOUS VALUE IS GIVEN).
C PASHIN, PASHMAX, ARE FOR REMEMBERING PREVIOUS VALUE OF XMIN, XMAX.
C DIMENSION CHARS(8), PLOT(111), OROPT(6), XN(6)
C EQUIVALENCE (OROPT(6),PLOT(6))
C DATA CHARS(1)/1H1/, CHARS(2)/1H2/, CHARS(3)/1H3/, CHARS(4)/1H4/,
C *CHARS(5)/1H5/, CHARS(6)/1H6/, CHARS(7)/1H /, CHARS(8)/1H./
C DATA NCALLS/0,NOY/0/
C IF(INIT)1000,1000,9001
CALL WAS TO INITIALIZE ONLY....
1000 NOY=0
NCALLS=0
GO TO 701
COMMENCE BY PROTECTING THE INDEX MX
9001 M=MAXO(MX,1)
M=MINO(M,6)
CONJURE PLOTTING CHARACTERS
3 XN(1)=X1
XN(2)=X2
XN(3)=X3
XN(4)=X4
XN(5)=X5
XN(6)=X6
IF(NOY) 15,15,28
28 IF(PASHMAX-XMAX) 45,40,45
40 IF(PASHMIN-XMIN) 45,80,45
15 NOY=1
COMPUTE AND PRINT ORIGINATE POINTS, SCALE.
45 AN=(XMAX-XMIN)*.2
OROPT(1)=XMIN
NCALLS = 0
OO 17 I=2,6
17 OROPT(I)=OROPT(I-1)+AN
WRITE (6,100) (OROPT(N),N=1,6)
OO 705 N=1,2
WRITE (6,101)
705 CONTINUE
101 FORMAT( 9X1H.,5(21X1H.))
WRITE (6,800)
800 FORMAT( 9X111(1H.))
100 FORMAT(1H1,4(E10.3,12X),E10.3,11X,E10.3)
DELTA=(XMAX-XMIN)/110.
CLEAR PRINTER LINE.
80 OO 99 K=2,111
PLOT(K)=CHARS(7)
99 CONTINUE
PLOT(1)=CHARS(8)
CAUSE X TO BE PUT ON THE INTERVAL (1,111).
20 OO 34 N=1,M
LOC=1.5*(XN(N)-XMIN)/DELTA
CHECK FOR X WITHIN THE INTERVAL (XMIN,XMAX),
IF(LOC) 34,34,811
811 IF(111-LOC) 34,814,814
CHARACTERS FOR PRINTING NOW GET DROPPED INTO PLACE.
814 PLOT(LOC)=CHARS(N)

```



```

      I      SPRECIP(372),SPREQV(372),SUBTITL(8)
COMMON TCOEFF,TEMPMAX,TEMPMIN,THRESHLO,TITLE(8),TOTPREC
COMMON USEMEAN
COMMON XMAX
INTEGER ACTOATE
INTEGER DATE,DATES,DREAOY
INTEGER FOOTNOT
INTEGER PASTINT,PLOTOBS,PLOTWE
INTEGER SUBTITL
INTEGER TITLE
INTEGER USEMEAN
C-----CHECK THE LINE COUNTER
IF(LINES - 48) 40,10,10
C-----SEE IF THIS IS STARTING A NEW STATION - IF SO, BYPASS THE FOOTNOTE
10 IF(LINES - 999) 20,30,30
C-----WRITE THE FOOTNOTE
20 WRITE (6,910) FOOTNOT
910 FORMAT(IH013A10/1X3A10)
C-----HEADINGS
30 WRITE (6,920) TITLE,SUBTITL
920 FORMAT(1H150X*SNOWMELT RUNOFF SIMULATION MODEL*/27X8A10/27X8A10)
WRITE (6,930) TCOEFF,COVENV
930 FORMAT(* TRANSMISSIVITY COEFFICIENT =*F4.2,*74X*COVER DENSITY =*F7.2
1)
WRITE (6,940)
940 FORMAT(*0*32X*TEMPERATURE (F)      PRECIP (IN)      NET RAD (CAL)
1ENERGY      SNOWPACK      PREDICTED*/
223X*DATE      MAX      MIN      AVE      DAY      ACCUM      SHORT      LONG B
3AL (CAL) TEMP (C) W.E. (IN)*/))
LINES = 0
40 WRITE (6,950) DATES,TEMPMAX,TEMPMIN,AVETEMF,PRECIP,TOTPREC,RAOSWN,
1 RADLWN,ENG8AL,PACKTEM,PREEQV
950 FORMAT(IH020X12,213,1X3F6.1,2F7.2,3X3F8.1,6XF5.1,5XF6.2)
LINES = LINES + 2
RETURN
END
111      35      40      -450      634      6000

```

```

SUBROUTINE WRITER (COOE)
C-----THIS SUBROUTINE KEEPS TRACK OF THE PRINTING DETAILS
COMMON ACTOATE,ACTUAL(21),AVETEMC,AVETEMF
COMMON BASTEMF
COMMON CALAIR,CALOEF,CALORIE,CALSNOV,COVDEN
COMMON OATE,OATES(3),OEN,DENSITY,OREADY
COMMON ENG8AL
COMMON FOOTNDT(I6),FREEWAT
COMMON HOLDCAP
COMMON IOATE(372),ISNOW,ITABLE
COMMON KOUNT
COMMON LASTUSO,LINES
COMMON NEXTACT
COMMON OBSWEQV
COMMON PACTME,PARTICE,PASTINT,PLOTBS,PLOTWE,PRECIP,PREWEQV
COMMON RADIN,RADLWN,RADSWN,REFLECT
COMMON SIMTEMI(3),SIMTEMD,SIMTEM3,SNOMELT,$OBSEQV(372),

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[illegible]

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

1973. Computer simulation of snowmelt within a Colorado sub-alpine watershed. USDA For. Serv. Res. Pap. RM-99, 22 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

A dynamic model which simulates snowmelt in Colorado sub-alpine watersheds for all combinations of aspect, slope, elevation, and forest cover composition and density is described. The model simulates winter snow accumulation, the energy balance, snowpack condition, and resultant melt in time and space. Detailed flow chart descriptions of the various components of the model and a program listing are presented.

Keywords: Computer models, coniferous forests, model studies, simulation analysis, snowmelt, watershed management.

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