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The Snowmelt-Runoff Model (SRM) User's Manual

J. Martinec,
A. Rango,
and E. Major

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The Snowmelt-Runoff Model (SRM) User's Manual

J. Martinec
Federal Institute for Snow and Avalanche Research
Weissfluhjoch/Davos, Switzerland

A. Rango
Goddard Space Flight Center
Greenbelt, Maryland

E. Major
Research and Data Systems, Inc.
Lanham, Maryland

NASA
National Aeronautics
and Space Administration

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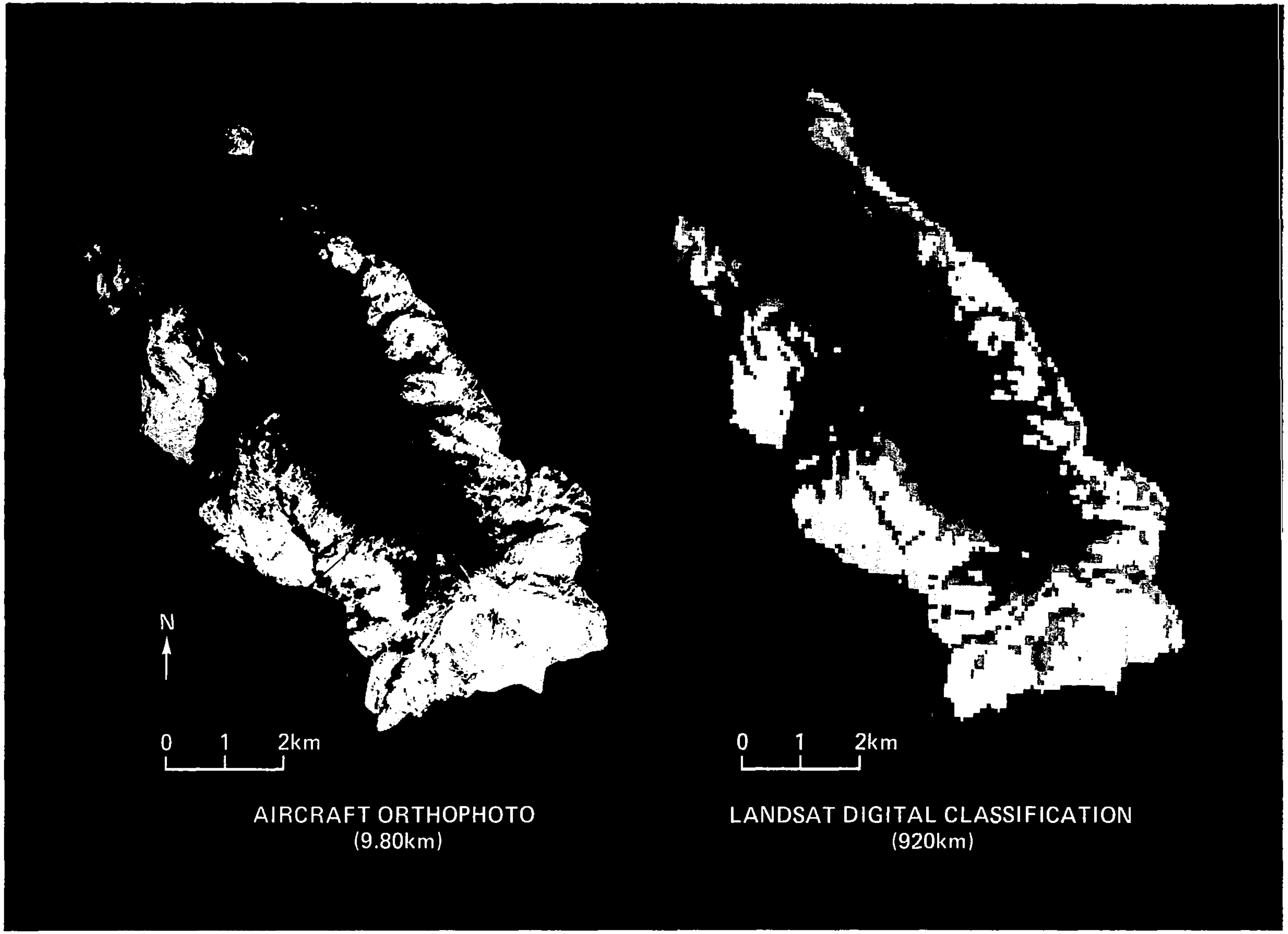

Frontispiece. Comparison of snow cover in the representative basin Dischma (Swiss Alps) on 8 June 1976 from two different altitudes.

PREFACE

The purpose of this manual is to provide a means by which a user may apply the snowmelt-runoff model (SRM) unaided. To this effect, model structure, conditions of application, and data requirements, including remote sensing, are described. Guidance is given for determining various model variables and parameters. Possible sources of error are discussed and conversion of SRM from the simulation mode to the operational forecasting mode is explained. A computer program is presented for running SRM which should be easily adaptable to most systems used by water resources agencies.

In view of the variety of snowmelt conditions that may be encountered, it is not possible to foresee all situations in which the model may be applied. The authors will be glad to assist users with specific problems that may not be answered by the manual.

Special gratitude is extended to the Goddard Space Flight Center and the Federal Institute for Snow and Avalanche Research for their support of this international scientific cooperation.

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THE SNOWMELT–RUNOFF MODEL (SRM) USER'S MANUAL

J. Martinec
Federal Institute for Snow and Avalanche Research
Weissfluhjoch/Davos, Switzerland

A. Rango
Goddard Space Flight Center
Greenbelt, Maryland

E. Major
Research and Data Systems, Inc.
Lanham, Maryland

INTRODUCTION

The snowmelt–runoff model (SRM; also referred to in the literature as the "Martinec Model" or "Martinec-Rango Model") is designed to simulate and forecast daily streamflow in mountain basins where snowmelt is a major runoff factor. SRM was developed by Martinec (Reference 1) in small European basins. With the advent of satellite snow–cover data in the 1970s, it became possible to test SRM in larger basins. Using Landsat data the model was successfully applied to various basins in the U.S.A. (References 2,3, and 4). Figure 1 illustrates the relative size of some of the basins in which the model has been tested so far. Based on these tests, the model was adapted to a wide range of basin and data characteristics.

RANGE OF CONDITIONS FOR MODEL APPLICATION

Basin Conditions

The size of the basin to which SRM is applied does not yet seem to be a limiting factor. The model so far has been used on basins ranging from 2.65 km^2 to 4000 km^2 (Kings River, California; Reference 5) with no serious problems encountered. As pointed out by Rango and Martinec (Reference 6), however, the accuracy of simulation generally decreases as the basin size increases because of sparse hydrometeorological data networks.

As already mentioned, SRM is to be used in a mountain basin with significant snow accumulation. The total basin relief (amplitude of elevation) encountered on watersheds tested so far has ranged between 350 and 4000 m. No problems are envisaged in application of the model to basins with a greater total relief, however, in basins with less total relief problems may arise due to the fact that SRM may not be applicable to non–mountain basins.

SRM has been used in mountain basins ranging in climate conditions from humid to semi–arid with no serious limitations. It seems, however, that simulations tend to be less accurate when there are significant amounts of rainfall during the snowmelt period.

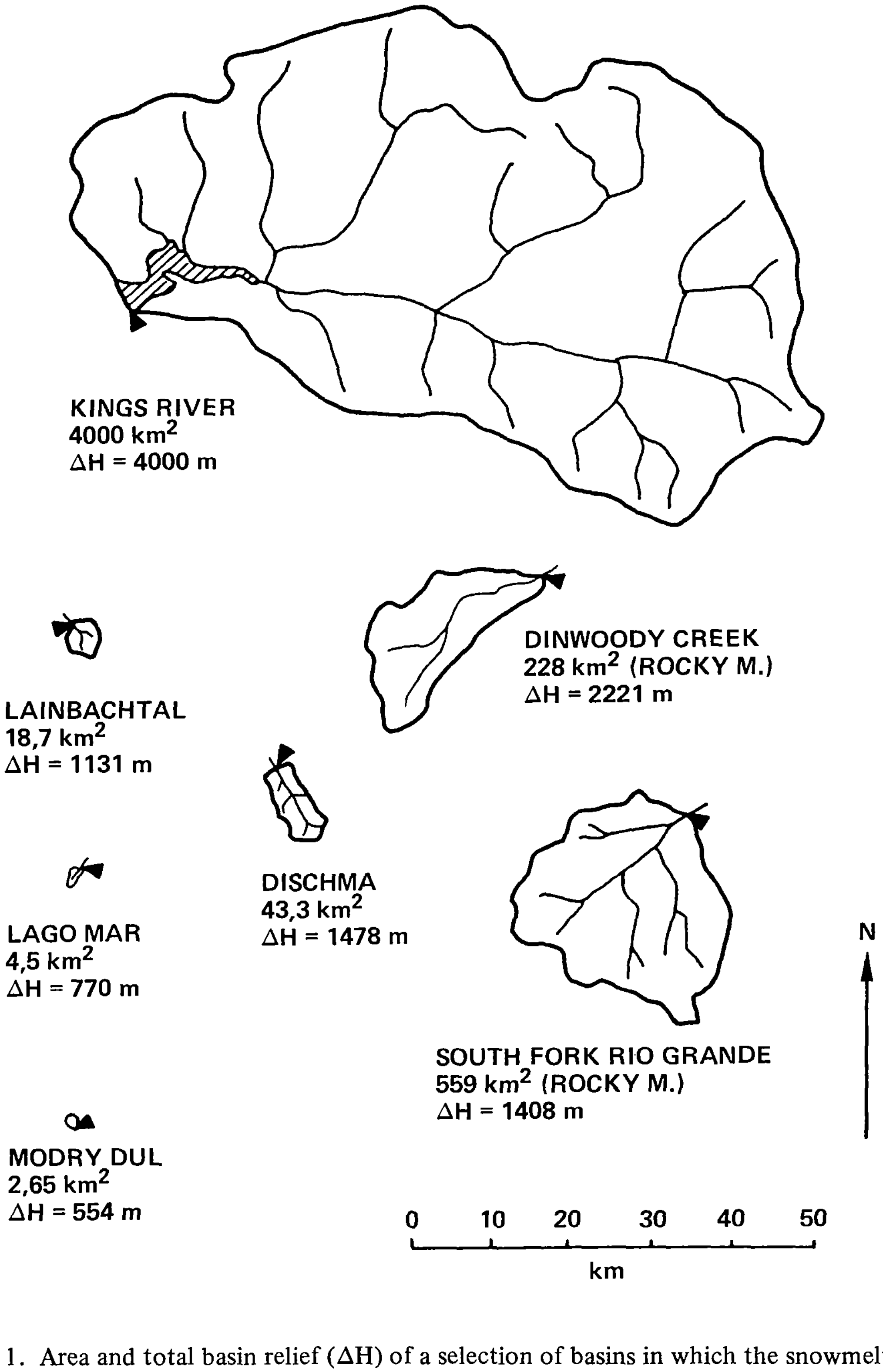


Figure 1. Area and total basin relief (ΔH) of a selection of basins in which the snowmelt-runoff model has been applied.

Data Quality

The model requires good daily air-temperature and precipitation data and periodical monitoring of snow-covered area in the given basin by satellites, aircraft, or visual observations. Long term historical data sets are not necessary (but helpful, if available) because little or no optimization (calibration) of the model parameters is necessary. The model can be run with as little as 1-2 years of record.

Daily discharge data from the basin are required to determine the recession coefficient and, otherwise, only to evaluate the accuracy of simulation. The discharge preceding the start of the snowmelt season (winter baseflow) must be known or estimated for initializing the model. Past continuous discharge records (hydrographs), if available, are useful to determine the time lag between the temperature and discharge cycles.

The optimum conditions for accurate simulation of runoff have been identified as follows (Reference 6): (1) temperature and precipitation are recorded at the mean elevation of the basin inside the basin boundaries (or at the zonal mean elevation for large basins); (2) snow cover is available reliably once per week to detect short-term variations in zonal areal extent; (3) several climatological stations are available for large basins, especially in areas with frequent summer precipitation events; and (4) several years of daily runoff records have been acquired for the determination of the recession coefficient. Decreases in accuracy will be expected as these optimum conditions are compromised. However, acceptable simulations will result even under the following minimum conditions; (1) temperature and precipitation data are observed outside the basin at a considerable horizontal and vertical distance; (2) snow-cover observations are only available two to three times during the snowmelt season; (3) climatological observations are not possible at multiple stations; and (4) no runoff records are available so that the recession coefficient must be estimated from the basin size (see section Recession Coefficient).

MODEL OUTPUT PRODUCTS

In the simulation mode, SRM produces daily discharge values from the start until the end of the snowmelt period (usually 1–6 months) using the actual sequence of temperatures and the depletion curves of the snow coverage obtained from snow-cover monitoring. Because updating is not necessary, no measured discharge values are required. Consequently, simulations can serve not only for model testing but also serve to establish discharge series in ungauged basins. Instead of real temperatures, hypothetical values can be substituted in order to simulate, for example, the effect of future changes of climate on the runoff. Seasonal volume simulations are obtained by summing the daily flows over the period of interest. Outside the snowmelt period, SRM can be operated but careful attention must be paid to the runoff coefficients in which are included the effects of evapotranspiration and soil moisture which are not as important during snowmelt.

For operational short-term discharge forecasts, SRM is run with similarly short-term temperature and precipitation forecasts and extrapolations of the snow-cover depletion curves. The forecasting period can be from 1 day to several weeks depending on the range of temperature forecasts. In such a forecast mode, periodical updating with actual temperatures and discharges and with recent snow-cover information is desirable. The model can also be used for seasonal forecasts of the expected runoff volumes ranging from several weeks to the total duration of the snowmelt season. Such forecasts are based on medium-range prediction techniques, climatological records, or on statistically determined sequences of temperatures and precipitation. An extrapolation of the snow-cover depletion curves taking into account the forecasted temperatures is also required.

MODEL STRUCTURE

Each day during the snowmelt season, the water produced from snowmelt and from rainfall is computed, superimposed on the calculated recession flow, and transformed into the daily discharge from the basin according to Equation (1).

$$Q_{n+1} = c_n \left[a_n \left(T_n + \Delta T_n \right) S_n + P_n \right] \frac{A \cdot 0.01}{86400} \left(1 - k_{n+1} \right) + Q_n k_{n+1} \tag{1}$$

where

Q = average daily discharge in $m^3 s^{-1}$

c = runoff coefficient expressing the losses as a ratio (runoff/precipitation)

a = degree-day factor ($cm \cdot {}^\circ C^{-1} \cdot d^{-1}$) indicating the snowmelt depth resulting from 1 degree-day

T = number of degree-days ($^\circ C \cdot d$)

ΔT = the adjustment by temperature lapse rate necessary because of the altitude difference between the temperature station and the average hypsometric elevation of the basin or zone

S = ratio of the snow-covered area to the total area

P = precipitation contributing to runoff (cm). A preselected threshold temperature, T_{CRIT}, determines whether this contribution is rainfall and immediate.

A = area of the basin or zone in m^2

$\frac{0.01}{86400}$ = conversion from $cm \cdot m^2 \cdot d^{-1}$ to $m^3 \cdot s^{-1}$

k = recession coefficient indicating the decline of discharge in a period without snowmelt or rainfall: $k = \frac{Q_{m+1}}{Q_m}$

(m, m+1 are the sequence of days during a true recession flow period)

n = sequence of days during the discharge computation period. Equation (1) is written for a time lag between the daily temperature cycle and the resulting discharge cycle of 18 hours. As a result, the number of degree-days measured on the nth day corresponds to the discharge on the n+1 day. Different lag times will result in the proportioning of day n snowmelt between discharges occurring on days n, n+1 and possibly n+2.

Data available in English units can be converted into the SI system and vice versa by the following conversion factors:

Conversion Factors

$Q[m^3 s^{-1}]$	$= 0.02832\ Q[ft^3 s^{-1}]$
$Q[ft^3 s^{-1}]$	$= 35.31\ Q[m^3 s^{-1}]$
$A[km^2]$	$= 2.59\ A[mi^2]$
$A[mi^2]$	$= 0.386\ A[km^2]$
$T[^\circ C \cdot d]$	$= 5/9\ T[(^\circ F - 32) \cdot d]$
$T[(^\circ F - 32) \cdot d]$	$= 9/5\ T[^\circ C \cdot d]$

$$a[\mathrm{cm \cdot {}^\circ C^{-1} \cdot d^{-1}}] = 4.57\, a[\mathrm{in \cdot ({}^\circ F{-}32)^{-1} \cdot d^{-1}}]$$
$$a[\mathrm{in \cdot ({}^\circ F{-}32)^{-1} \cdot d^{-1}}] = 0.22\, a[\mathrm{cm \cdot {}^\circ C^{-1} \cdot d^{-1}}]$$
$$P[\mathrm{cm}] = 2.54\, P[\mathrm{in}]$$
$$P[\mathrm{in}] = 0.39\, P[\mathrm{cm}]$$

For Q in $ft^3\ s^{-1}$, a in in $\cdot$ (°F–32°) $\cdot\ d^{-1}$, T in (°F–32°) $\cdot$ d, P in in and A in mi^2, the conversion constant 0.01/86400 in Equation (1) becomes 2323200/86400. For A in ft^2, the conversion constant becomes 0.0833/86400.

In Equation (1), T, S, and P are variables to be measured or determined each day; whereas, c, a, k, and ΔT are parameters which are characteristic for a given basin or, more generally, for a given climate. The parameters are evaluated before hand from actual data, observations, or prior knowledge, or they are estimated by analogy from other basins. In addition, the area–elevation curve of the basin is required in order to determine the altitude difference for the extrapolation of temperature. If the elevation range of the basin exceeds 500 m, it is recommended to divide the basin into elevation zones of about 500 m each. For an elevation range of about 1500 m and three elevation zones A, B, and C, the model equation becomes:

$$\begin{aligned} Q_{n+1} = {} & c_{An}\,[a_{An}\,(T_n + \Delta T_{An})\,S_{An} + P_{An}]\,\frac{A_A \cdot 0.01}{86400} + \\ & c_{Bn}\,[a_{Bn}\,(T_n + \Delta T_{Bn})\,S_{Bn} + P_{Bn}]\,\frac{A_B \cdot 0.01}{86400} + \\ & c_{Cn}\,[a_{Cn}\,(T_n + \Delta T_{Cn})\,S_{Cn} + P_{Cn}]\,\frac{A_C \cdot 0.01}{86400}\,(1 - k_{n+1}) + Q_n\,k_{n+1} \end{aligned} \tag{2}$$

The indices A, B, and C refer to the appropriate elevation zone, and, again, a time lag of 18 hours is assumed.

In the simulation mode, the model can function without updating during the snowmelt period. The discharge data serve only to evaluate the accuracy of the simulation. In ungauged basins the simulation is started with a discharge estimated by analogy to a nearby gauged basin. In the forecasting mode, if the discharge data are available, the model provides an option for updating on a periodic basis with actual discharge.

DETERMINATION OF MODEL VARIABLES AND PARAMETERS

Basin Characteristics

Basin and Zone Areas

The basin boundary is defined by the location of the streamgauge (or some arbitrary point on the streamcourse) and the watershed divide as identified on a topographic map. The basin boundary can be drawn on a variety of map scales. For the larger basins, a 1:250,000 scale map is adequate. After examining the elevation range between the streamgauge and the highest point in the basin (total basin relief), elevation zones can be delineated in intervals of about 500 m or 1500 ft. In addition to drawing the basin and zone boundaries, several intermediate topographic contour lines should be highlighted for later use in constructing the area–elevation curve. Once the boundaries and the contours have been determined, the areas formed by these boundaries should be planimetered, manually or automatically. Figure 2 shows the elevation zones and areas of the

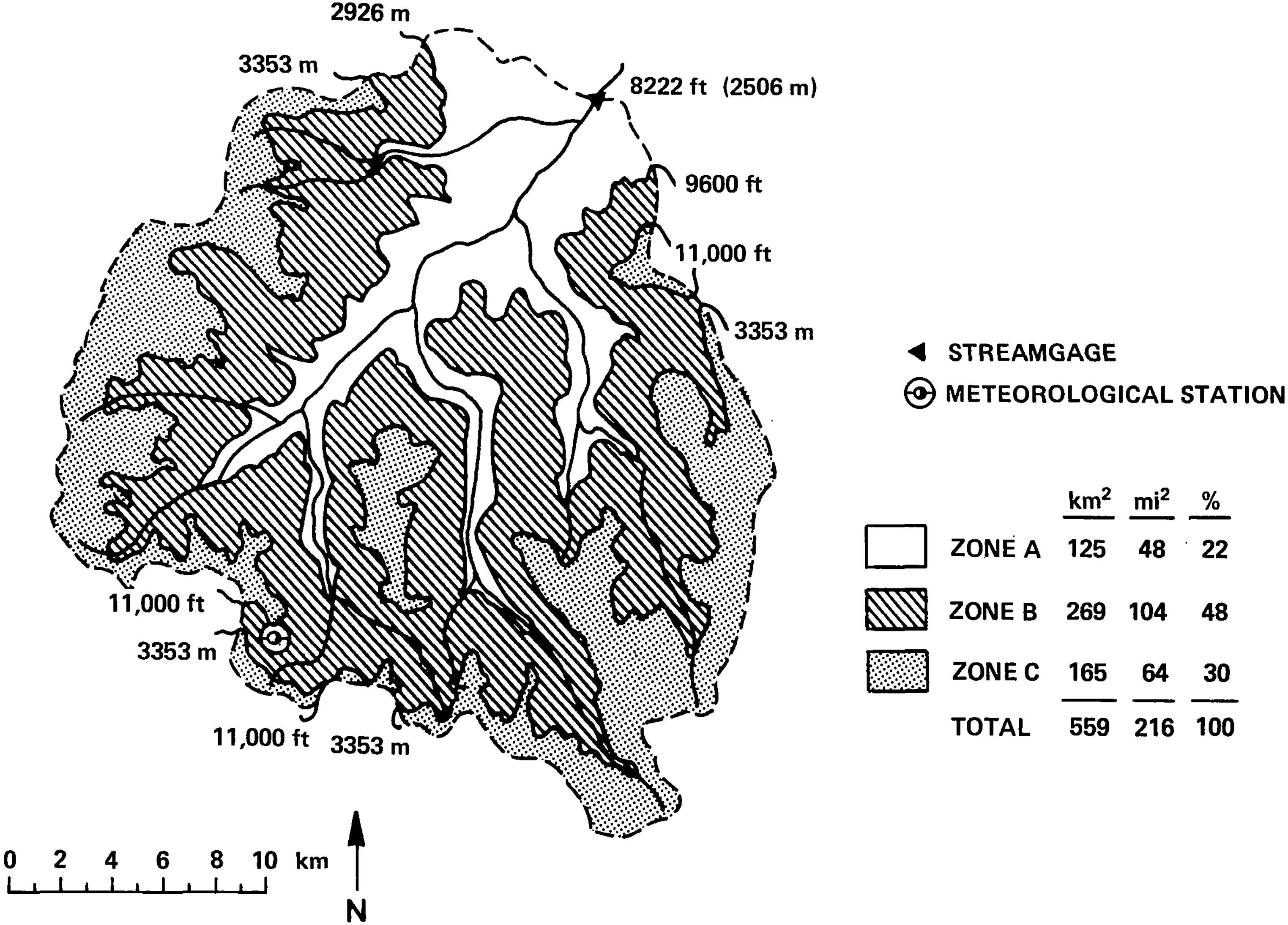


Figure 2. Elevation zones and areas of the South Fork of the Rio Grande basin, Colorado, U.S.A.

South Fork of the Rio Grande basin in Colorado, U.S.A. The elevation range of 1408 m dictated the division of the basin into three elevation zones. Once the zones are defined, the various model variables and parameters are applied to each zone for the calculation of snowmelt runoff. To facilitate this application, the mean hypsometric elevation of the zone must be determined through use of an area-elevation curve.

Area-Elevation Curve

By using the zone boundaries plus other selected contour lines in the basin, the areas enclosed by various elevation contours can be determined by planimetering. These data can be plotted (area vs. elevation) and an area-elevation (hypsometric) curve drawn as shown in Figure 3 for the South Fork basin. The zonal mean hypsometric elevation, $\bar{h}$, can then be determined from this curve by balancing the areas above and below the mean elevation as shown in Figure 3. The $\bar{h}$ value is used as the elevation to which base station temperatures are extrapolated for the calculation of zonal degree-days.

Variables

Temperature and Degree-Days

Although a minimum of one temperature station is required in order to apply SRM to a given basin, the ideal situation would have temperature measurements made at the $\bar{h}$ of each elevation zone. As this is usually not the case, the location of one temperature station at the mean hypsometric elevation of the entire basin would be desirable. Both of these situations minimize the vertical distance that temperatures would have to be extrapolated for application in the model. If this is not possible, the use of two stations, one at the bottom of the basin and one near the top would permit computation of an actual temperature lapse rate to be used in extrapolation to the various zones. Usually, however, data from only one temperature station at low elevation, and many times not even located inside the basin, must be used to calculate the degree-days for melting snow in the lowest to the highest elevation zones of the basin. When one station is used, a lapse rate has to be assumed in order to extrapolate degree-days from the base station to the appropriate mean hypsometric elevation.

Air temperature expressed in degree-days is used in SRM as an index of the complex energy balance leading to snowmelt. At stations where hourly readings are made, the number of degree-days for each 24-hour period is determined by summing the hourly temperatures and dividing by 24 and using 0°C as the base temperature. Where only maximum and minimum temperatures (T_{max}, T_{min}) are available, the number of degree-days (in°C) is determined as

$$T = \frac{T_{max} + T_{min}}{2} \tag{3}$$

The degree-day figures refer to the 24-hour period starting at 0600 hours with the corresponding discharge referring to periods shifted according to the time lag of the basin. As indicated by Linsley, *et al.* (Reference 7), all negative differences in the degree-day values in Equation (3) are taken as zero.

There are several methods for dealing with the actual temperatures used in calculating the degree-day value. When using the max–min approach, the most common way is to use the temperatures as they are recorded and calculate the average daily temperature. Garstka, *et al.* (Reference 8), however, indicate that in many parts of the mountainous western United States the fluctuation of

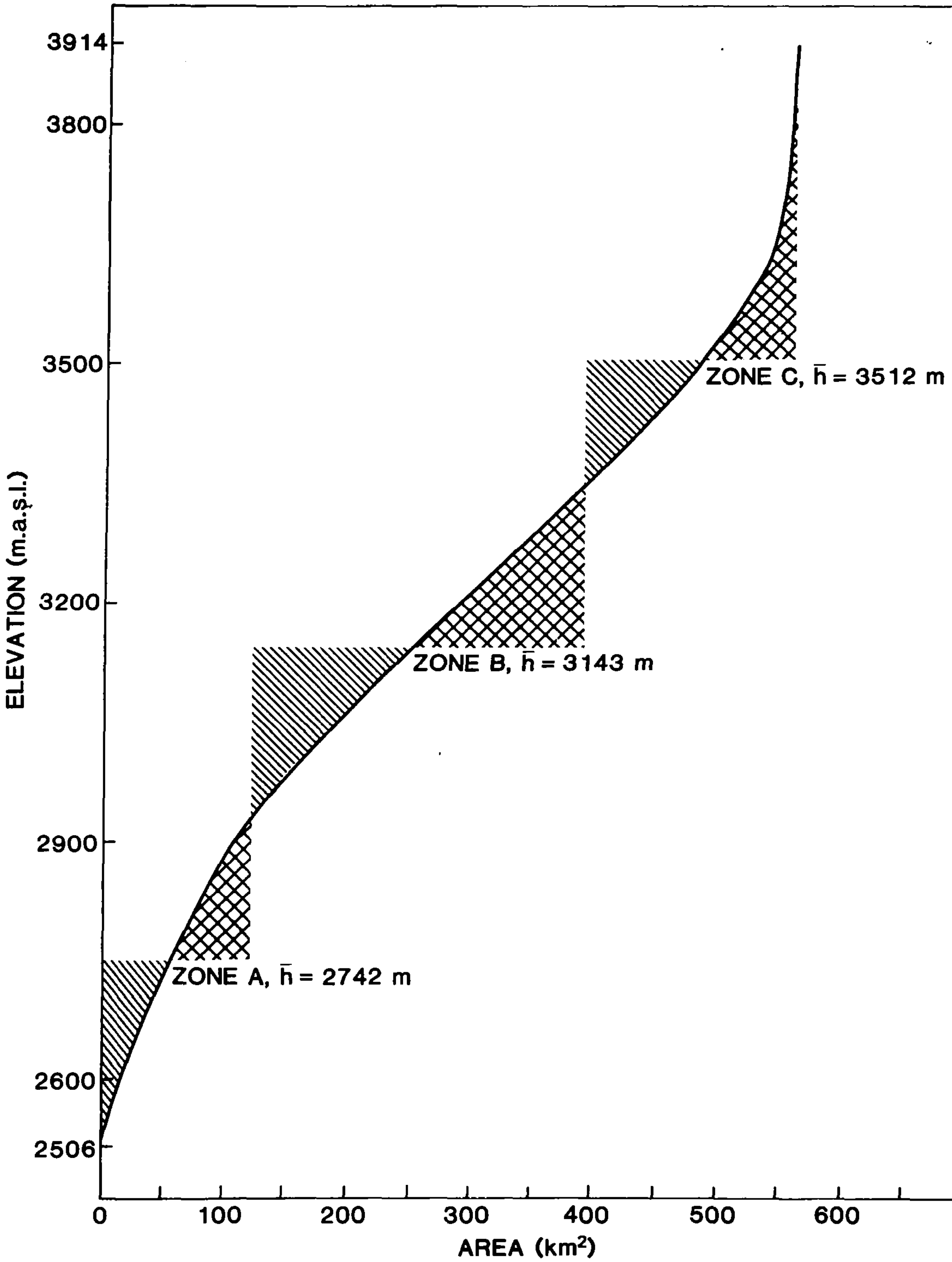


Figure 3. Determination of zonal mean hypsometric elevations ($\bar{h}$) using an area–elevation for the South Fork of the Rio Grande basin.

temperatures, especially the depression of the minimum, is very large so that the average temperature will many times turn out to be below 0°C indicating no degree-days. Even so, during part of the day snowmelt conditions may have prevailed due to temperatures reaching as high as 10–15°C. In order to counteract this problem, an effective minimum temperature approach can be used. In essence, whenever T_{min} <0°C it becomes T_{min} = 0°C before being entered into Equation (3). It appears that this approach gives a better representation of the heat factor for use in snowmelt-runoff studies (Reference 8). Treating minimum temperatures below the freezing point as 0°C can also be employed when using hourly temperatures to calculate the degree-days. If all hourly temperatures of both T_{max} and T_{min} are below 0°C, however, then the degree-days are taken as zero. It is recommended to use the effective minimum temperature approach for calculating degree-days for use in SRM. The model and computer program can also accept the average temperature approach, however, if the user feels that it better represents the snowmelt conditions in a given basin.

The degree-days are extrapolated to an elevation zone by using a suitable lapse rate, δ, and the following equation.

$$\Delta T = \delta \, (h_{ST} - \bar{h}) \tag{4}$$

where

ΔT = temperature lapse rate correction factor in °C

δ = temperature lapse rate in °C per 100 m

h_{ST} = altitude of the temperature station in m

$\bar{h}$ = zonal hypsometric mean elevation in m

The temperature lapse rate must be carefully determined, especially if the observation station is situated at a low altitude and the extrapolation of degree-days is made in only one direction (upwards). The lapse rate should be indicative of the mountainous region where the basin is located based on some kind of prior climatic knowledge. As the snowmelt season progresses, lapse rates may change depending on the basin. Such changes can be instituted every 15 days in SRM, if necessary. When applying SRM it is advisable to conduct a regional analysis of monthly lapse rates to determine the seasonal variation. In some cases it may be necessary to modify the mean monthly lapse rates obtained in such an analysis because of basin peculiarities (such as frequent temperature inversions) or an abnormal climatic progression in a particular year. In basins with little seasonal variation, a lapse rate of 0.65°C/100m has been found to be adequate.

Precipitation

It is even more difficult to obtain adequate precipitation data for a mountain basin than to obtain temperature data. The extrapolation of precipitation amounts from one or more base stations to zones in the basin must be done based on user knowledge of the study area. Location of a precipitation station at the mean hypsometric elevation would be the optimum situation.

If precipitation is determined to fall in the basin on a given day, a critical temperature, T_{CRIT}, must be examined to determine whether the precipitation is rain or snow. T_{CRIT} is usually selected to be slightly above the freezing point and may vary from basin to basin. The distinction between rain and snow is important in SRM because the rain contribution to runoff is on the same day that the rain occurs, whereas the snow contribution to runoff is delayed.

When the precipitation is determined to be snow, its delayed effect on runoff is treated differently depending on whether it falls over the snow-covered or snow-free portion of the basin. The new snow that falls over the previously snow-covered area is assumed to become part of the seasonal snowpack and its effect is included in the normal depletion curve of the snow coverage. The new snow falling over the snow-free area is considered as precipitation to be added to snowmelt, with this effect delayed until the next warm day. This precipitation is stored by SRM and then melted as soon as a sufficient number of degree-days has occurred. This may take place on the first day warm enough to produce snowmelt or on a series of days. The following example in Table 1 illustrates a case where 2.20 cm water equivalent of snow fell on day n and then was melted on the three successive days.

Table 1. Calculation of the melt of new snow deposited on a snow-free area (P_n = 2.20 cm; T_{CRIT} = +1.0°C)

Day	a $(cm \cdot °C^{-1} \cdot d^{-1})$	T (°C · d)	S	P (cm)	Melted Depth $a \cdot T$(cm)	P Stored (cm)	P contributing to Runoff $a \cdot T \cdot (1-S)_{(cm)}$
n	0.45	0	0.72	2.20	0	2.20	0
n+1	0.45	0.11	0.70	0	0.05	2.15	0.02
n+2	0.45	2.70	0.68	0	1.22	0.93	0.39
n+3	0.45	3.70	0.66	0	0.93	0	0.32

In this example, S is decreasing on consecutive days because it is interpolated previously from the snow-cover depletion curve. In reality it should remain constant as long as the seasonal snowpack is covered with new snow, however, the model currently uses the incremental decrease of S shown in Table 1.

When the precipitation is determined to be rain, and it falls on a snow-free area, it becomes available to contribute to runoff immediately. When rain falls on snow, however, its effect on runoff depends upon the condition of the snowpack. Early in the snowmelt season rain falling on the snowpack is assumed to be retained by the snow, which is mostly dry and usually deep. This rainfall is not available for runoff. At some stage during snowmelt the snowpack is assumed to be ripe (the user must decide when), and any rain falling on the snow is transferred through the snow layer and becomes available to contribute to runoff the same as over the snow-free area. Both of these options are included in the computer program. In SRM the melting effect of rainfall is neglected.

Snow Coverage

The snow-cover variable, S, of a zone or basin is usually obtained from a depletion curve for input into SRM. A variety of sources of snow-cover data can be used to compile the depletion curves including ground observations (used for Modrý Důl), aircraft photography (Dischma), and satellite imagery (all the large basins). If the data are available, it is recommended that satellite imagery be used since it is the easiest to analyze and also quite accurate depending on basin size (area minimums for various satellites: Landsat-10km^2; NOAA-VHRR-200km^2; and GOES-1000km^2). To assist in the use of satellite imagery for snow-cover interpretations, a handbook of analysis techniques is available (Reference 9). Additional information on snow-cover interpretation techniques for Europe is given in Reference 10.

Photointerpretation of satellite snow images is used to delineate the snow line on a base map of the study basin (see Figure 2), and the area enclosed by the snow line in each elevation zone is planimetered to obtain the snow-covered area. The snow cover by elevation zone is then plotted against elapsed time to construct depletion curves such as those shown in Figure 4 for 1976 in the South Fork basin. For the snowmelt-runoff simulation, daily snow-cover values are taken from the depletion curves and input to SRM.

Snowstorms occurring during the snowmelt season can result in a temporary increase of snow cover, but generally with no significant hydrologic effect. The duration of this increase is usually shorter than the interval between snow-cover observations. If the snowstorm occurs shortly before the

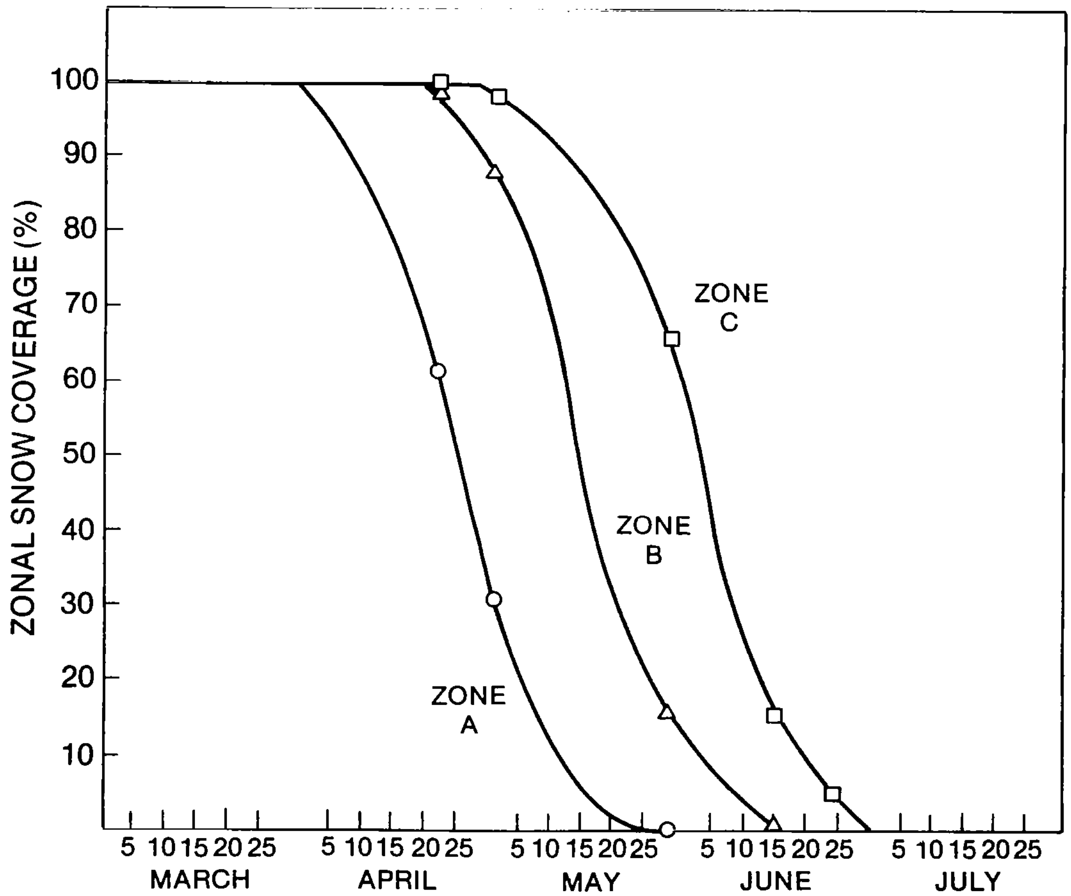


Figure 4. Landsat-derived snow-cover depletion curves for the South Fork of the Rio Grande basin for elevation zones, A, B, and C for 1976. Landsat snow-cover observations are plotted.

snow-cover observation, however, it may lead to the interpretation of exaggerated snow-covered areas and a distortion of the true depletion curves of the seasonal snowpack. It is recommended that such anomalous snow-cover values be disregarded and that the depletion curves be drawn only with reference to the snow cover accumulated before the beginning of the snowmelt period (seasonal or "old" snowpack), as illustrated in Figure 5. Precipitation and temperature records should be consulted in order to identify these transitory snow events when drawing the depletion curves. The transitory new snow is accounted for as stored precipitation eventually contributing to runoff as explained in the previous section.

In rare cases massive summer snowstorms can affect the snow coverage for several weeks. If such a situation is revealed by subsequent satellite data, it may be preferable to draw the depletion curves

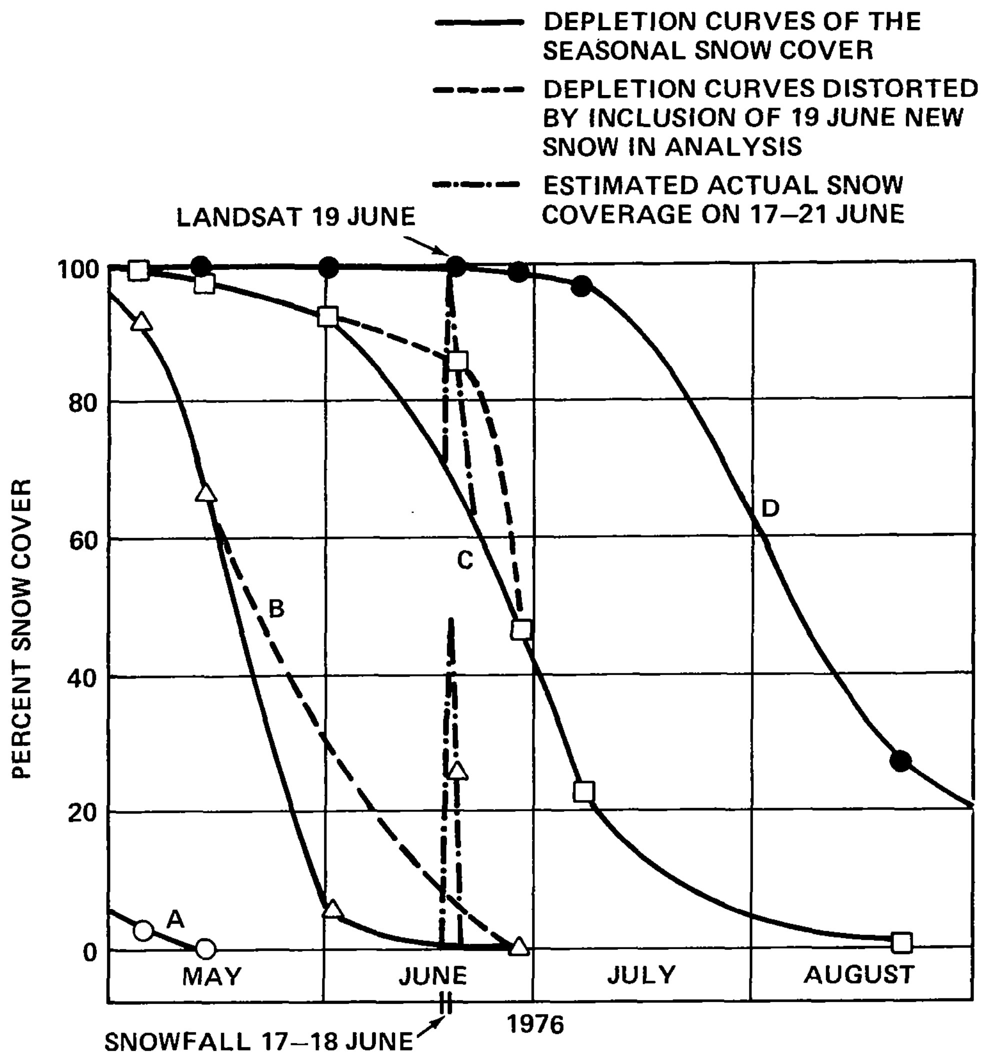


Figure 5. Seasonal and distorted depletion curves of snow coverage in the Dinwoody Creek basin, Wyoming, U.S.A. for elevation zones A, B, C, and D. A snow storm of 17–18 June deposited several cm water equivalent of new snow preceding the Landsat overpass of 19 June. The new snow in zones B and C was melted in 2–3 days.

according to this actual snow coverage. Because of this modification to the depletion curves, the model will melt more seasonal snow than before, but the amount of stored or new precipitation will be automatically reduced.

If runoff forecasts at the beginning of snowmelt are desired, a new approach must be used because the actual snow-cover depletion curves are not available, and in many cases, the snow-cover extent does not differ greatly between a dry and a wet year. The South Fork basin (559 km^2) in Colorado was studied as an example. Although the runoff in the snowmelt season of 1979 was six times greater than it was in the drought year of 1977, there was little difference in the snow-cover extent of the upper elevation zones of the South Fork basin on 1 April. To provide a means for forecasting runoff, it is suggested that the depletion curves that normally relate the areal extent of the snow cover to elapsed time be modified to relate the snow coverage to the accumulated degree-days (Reference 11). This procedure is discussed in more detail in the chapter on Operation of the Model for Real-Time Forecasts.

Parameters

Runoff Coefficient

The average value of the runoff coefficient, c, for a basin for a year is given by the ratio of annual runoff/annual precipitation. It should be pointed out that because of a measurement catch deficit, rain gauges frequently underestimate winter precipitation (snow) in mountain basins. As a result, artifically elevated values of c may be calculated. In such a case, a synthesis of data from representative basins should provide guidance for assessing c in the absence of reliable, direct measurements.

Because the runoff coefficient is likely to vary throughout the year as a result of changing vegetation and soil moisture conditions, the SRM computer program permits changes in c every 15 days. Usually, c is higher for snowmelt than for rainfall. Therefore, the model can handle different runoff coefficients for snow, c_S, and for rain, c_R, as determined by the user. In basins studied, when snowmelt is concentrated in a short time period, c_S can approach 1.0. With prolonged snowmelt runoff in a semiarid region, c_S may go down to 0.3. In addition c will vary from zone to zone in a basin, and SRM has the capability to handle different c values by zonal input. It is possible that with rain falling in the low elevations of a semiarid basin, c_R may be 0.2, whereas at the same time in the high elevations with snow still melting, c_S can be 0.9. The selection of c requires first hand knowledge of the basin and its hydrologic behavior under different hydrometeorological conditions.

Degree-Day Factor

The degree-day approach is used as an index of the energy balance and the degree-day factor, a, is used to convert degree-days to snowmelt expressed in depth of water. The degree-day factor is variable throughout the melt period because the changing properties of snow influence the melting process. It is possible to measure the degree-day factor at a point using temperature measurements and a snow pressure pillow or lysimeter. The simultaneously accumulated degree-days and melt at a pressure pillow can be compared to calculate the degree-day factor for different times during the snowmelt season. Daily values are extremely variable so it is recommended to use a minimum of 3-5 days for averaging the degree-day factor. In addition, point measurements cannot be easily extrapolated to large areas. The point measurements can be used for information and then weighted depending on how well a specific station represents the hydrologic characteristics of a given zone (Reference 12).

In the absence of detailed data, the degree-day factor can be obtained from an empirical relation developed by Martinec (Reference 13):

$$a = 1.1 \frac{\rho_s}{\rho_w} \tag{5}$$

where a = the degree-day factor in cm $\cdot °C^{-1} \cdot d^{-1}$
ρ_s = density of snow
ρ_w = density of water

The general seasonal increase in ρ_s can be used as an index of the seasonal increase of a. Large variations are expected if the melt season is long or there is a large difference in elevation in the basin. For Dinwoody Creek in Wyoming, a was gradually increased from 0.35 on 1 April to 0.60 on 30 September in the highest elevation zone (Reference 2).

A wide range of a values has been reported in the literature with a generally increasing as the snowpack ripens. There have been extreme values as low as 0.07 cm $\cdot °C^{-1} \cdot d^{-1}$ and as high as 0.92 cm $\cdot °C^{-1} \cdot d^{-1}$ reported (Reference 14), however, during the snowmelt season for undisturbed snow, the range is about 0.25 – 0.60 cm $\cdot °C^{-1} \cdot d^{-1}$. The fact that increasing a is related to increasing snow density as snowmelt progresses is in response to a number of factors. A greater density is usually associated with older snow with a lower albedo, thus a higher a value. In addition, high densities toward the end of the snowmelt season are also associated with increased liquid water content and low thermal quality of the snow. Because of these expected seasonal changes in a, SRM is structured to allow modifications of a every 15 days, if necessary. Because of different stages of snowpack ripening in different elevation zones, a can also be varied between zones. Sometimes the occurrence of a large, late season snowfall will produce depressed a values for several days due to the new low-density snow. The a values in the model can manually be modified and inserted to reflect these unusual snowmelt conditions.

Recession Coefficient

The recession coefficient, k, depends upon the current discharge in the following way:

$$k_{n+1} = xQ_n^y \tag{6}$$

where Q is the daily discharge and the constants x and y must be determined for the given basin. For this determination, daily discharge values for the snowmelt season or the whole year are used. The discharge on a given day, Q_n, is always plotted against the value on the following day, Q_{n+1}, as illustrated in Figure 6 for the Dischma basin in Switzerland. In Figure 6 any points above the 1 to 1 line refer to the rise of the hydrograph and the points below the line to the fall of the hydrograph. For purposes of this model and derivation of the recession equation, only points below the 1 to 1 line need to be plotted. Once these points have been plotted, an envelope line as shown in Figure 6 can be drawn to enclose most of the points. The lower envelope line represents the extreme discharge decline, i.e., the recession without any partial delay by possible precipitation or snowmelt. It is not recommended, however, to include all points inside this envelope at any cost, especially in the lower range of discharges. The reason for this is that some discharge values may be affected by non-typical phenomena such as icing conditions in the winter or the timing of rainfall which in a particular storm results in an abrupt decrease of discharge from one day to the next.

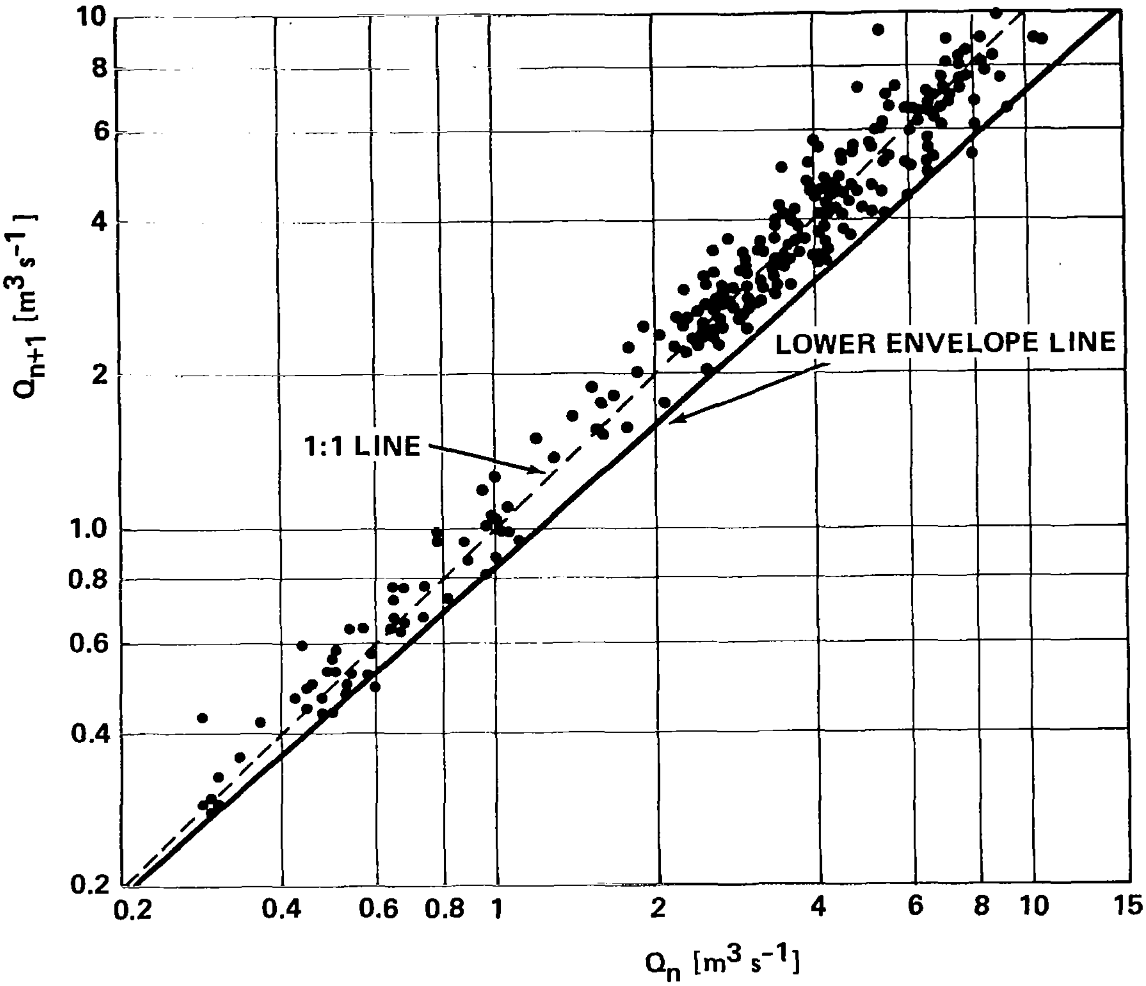


Figure 6. Recession flow plot, Q_n vs Q_{n+1}, for the Dischma basin in Switzerland with the lower envelope line drawn.

This lower envelope curve has been found to be valid on small size basins. When the model is applied to larger basins, however, it is recommended that the lower envelope curve be replaced with an average curve halfway between the lower envelope line and the 1 to 1 line. An average curve would also result from a least squares fit to the points, although the extra effort may not be justified. The average curve should probably be used on basins greater than about 50 km^2. For year-round simulations, it was found useful to derive the constants x and y for Equation (6) separately for the summer and winter half year.

For the Dischma basin (43.3 km^2) the lower envelope curve is shown in Figure 6. The constants x and y needed in the recession equation are computed by reading off a pair of recession coefficients (k_1, k_2) from Figure 6 corresponding to discharges Q_1 and Q_2 and by solving the following equations:

$$k_1 = x \cdot Q_1^y \tag{7}$$
$$k_2 = x \cdot Q_2^y \tag{8}$$

$$\log k_1 = \log x + y \log Q_1 \tag{9}$$

$$\log k_2 = \log x + y \log Q_2 \tag{10}$$

If the discharge range allows selection of $Q_1 = 1.0\ m^3 sec^{-1}$ and $Q_2 = 10.0\ m^3 sec^{-1}$ the solution is simplified and Equations (9) and (10) become:

$$\log k_1 = \log x$$
$$x = k_1$$

$$\log k_2 = \log x + y$$
$$y = \log k_2 - \log k_1$$

For the Dischma basin in Figure 6,

$$k_1 = 0.85 \text{ (for } Q_1 = 1.0\ m^3 sec^{-1})$$
$$k_2 = 0.697 \text{ (for } Q_2 = 10.0\ m^3 sec^{-1})$$

$$x = 0.85$$
$$y = \log 0.697 - \log 0.85 = -0.086$$

The recession equation for Dischma using the lower envelope curve thus becomes

$$k_n = 0.85\ Q_{n-1}^{-0.086} \tag{11}$$

For comparison of the recession equations of some of the previously studied basins, Figure 7 shows the plots and equations for five selected basins.

If no discharge data are available for a basin, recession coefficients can be estimated using the following formula (Reference 15):

$$k_{B2} = k_{B1}^{\sqrt[4]{A_{B1}/A_{B2}}} \tag{12}$$

where A_{B1} and A_{B2} are the respective areas of the basins B1 and B2 and k_{B1} and k_{B2} are the recession coefficients for the corresponding runoff conditions, e.g., the average discharge, in both basins. If the constants x and y are known in basin B1, it follows that for basin B2:

$$k_{B2n} = \left[x_{B1} \left(\frac{\bar{Q}_{B1}}{\bar{Q}_{B2}}\ Q_{B2n-1} \right)^{y_{B1}} \right]^{\sqrt[4]{A_{B1}/A_{B2}}} \tag{13}$$

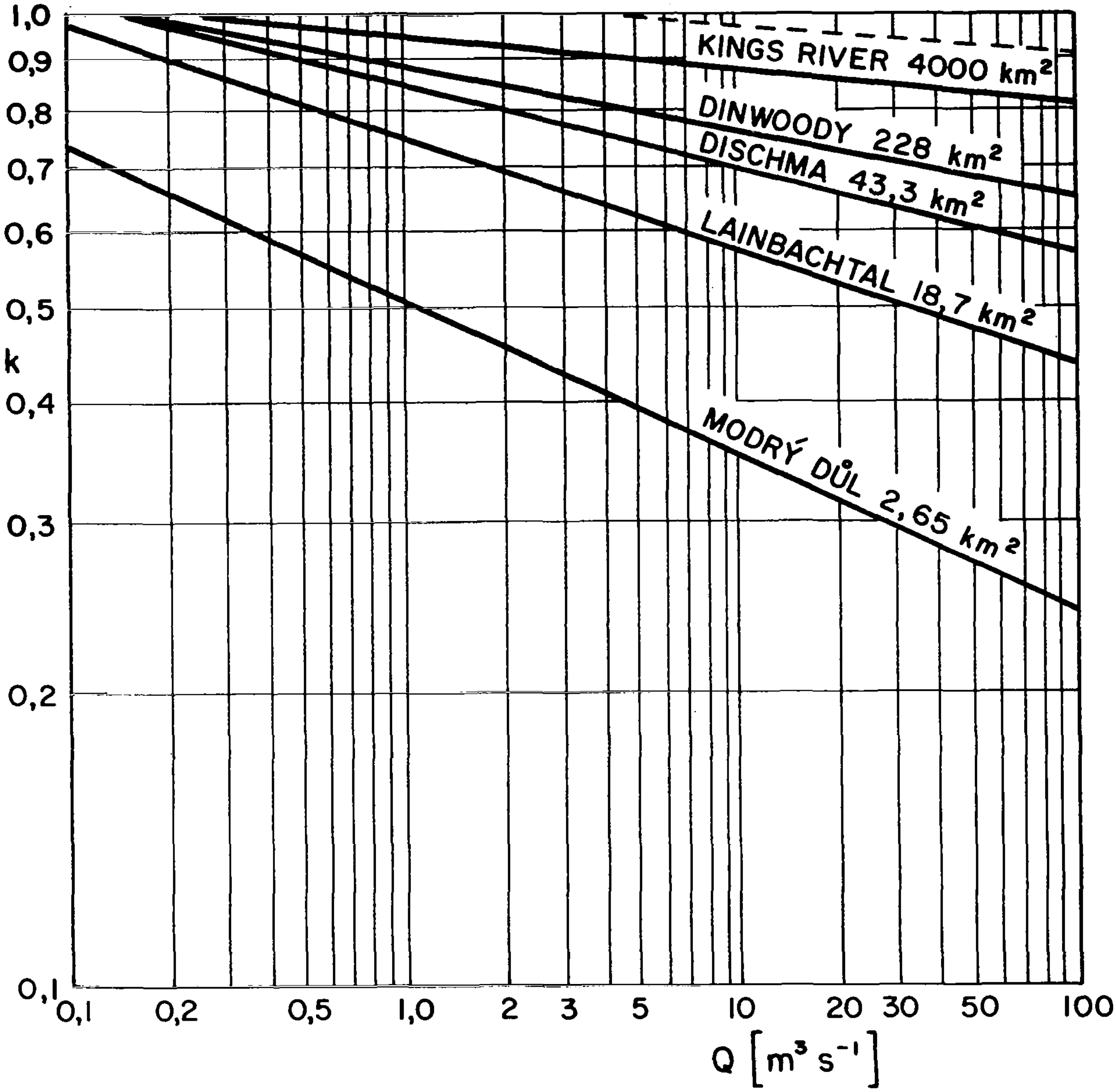


Figure 7. Relation of k and Q for basins of various sizes.

For example, if $x = 0.85$ and $y = -0.086$ have been derived for the Dischma basin, a relation for the Kings River basin is obtained by substituting $\overline{Q}_{DISCHMA} = 1.69\ m^3sec^{-1}$, $\overline{Q}_{KINGS} = 61.3\ m^3sec^{-1}$, $A_{DISCHMA} = 43.3\ km^2$, and $A_{KINGS} = 4000\ km^2$ into Equation (13).

$$k_{B2n} = \left[0.85\left(\frac{1.69}{61.3}\ Q_{B2n-1}\right)^{-0.086}\right]^{\sqrt[4]{43.3/4000}}$$

$$k_{B2n} = \left[0.85 \cdot 1.36\ Q_{B2n-1}^{-0.086}\right]^{0.3226}$$

$$k_{B2n} = \left[1.15\ Q_{B2n-1}^{-0.086}\right]^{0.3226}$$

$$k_n = 1.046\ Q_{n-1}^{-0.0277} \tag{14}$$

Equation (14) is the recession equation for the Kings River basin using the lower envelope curve as derived by the size relationship of Equation (12). Because of the size of the Kings River basin, further analysis is needed to yield the recommended average curve for the type of plot shown in Figure 6.

Using this approach, SRM could be used to simulate discharge in ungauged basins. The equation for the recession coefficient of an ungauged basin could be obtained from utilization of Equation (12) and the recession data from an already studied basin. The simulation would start on the first day of the snowmelt period by substituting a value for Q_0 corresponding to the winter baseflow into Equation (6) to calculate k_1. The winter baseflow value may be estimated by analogy with another basin or by measuring the discharge. Then k_1 and Q_0 are substituted into Equation (1) to calculate Q_1. Once the computation has started, subsequent k values are determined each day from Equation (6) by substituting computed values of Q.

Time Lag

Equations (1) and (2) correspond to the most simple case of a time lag of 18 hours. In this case, the temperature rise at 06:00 hrs results in the rise of the hydrograph at 24:00 hrs. Therefore, degree-days determined for a certain day with a minimum at 06:00 hrs and a maximum at about 14:00 hrs correspond to a discharge starting at 00:00 hrs the next day (see Figure 8). If the time lag is not conveniently 18 hours, the computed discharge values may have to be shifted by a certain number of hours to facilitate comparison with published streamflow data. Examples of such shifts are presented in the following.

If the time lag is 6 hours, degree-days for the nth day result in a discharge starting at 12:00 hrs on the same day and ending at 12:00 hrs on day n+1 as shown in Figure 8. The next day's discharge (Q_{n+1}) is composed of about one half of the calculated input from day n and one half from day n+1. In the simple case of one elevation zone the equation for Q_{n+1} would be:

$$\begin{aligned} Q_{n+1} = \Big\{ & 0.5\, c_n\, [a_n\ (T_n + \Delta T_n) S_n + 2\, P_n] + \\ & 0.5\, c_{n+1}\, [a_{n+1}\, (T_{n+1} + \Delta T_{n+1}) S_{n+1}] \Big\} \frac{A \cdot 0.01}{86400} (1 - k_{n+1}) \\ & + Q_n\, k_{n+1} \end{aligned} \tag{15}$$

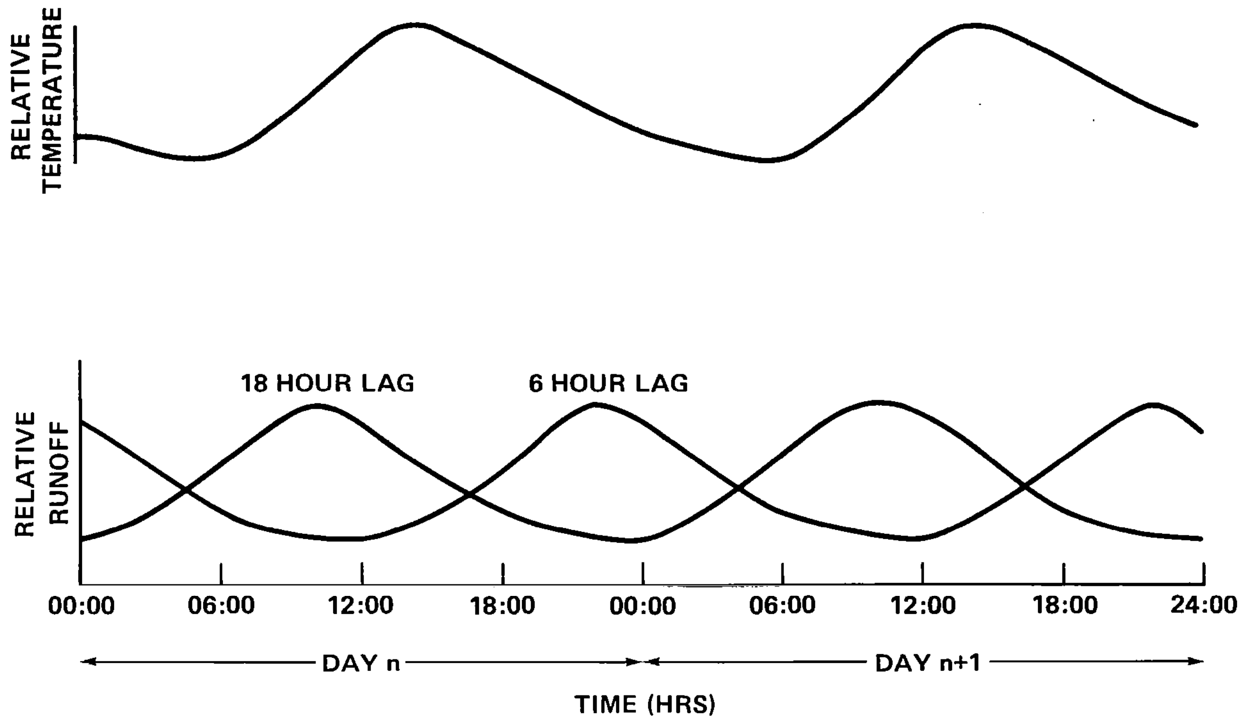


Figure 8. Daily fluctuations of temperature and discharge illustrating lag times of 6 and 18 hours.

In contrast to the snowmelt, the total amount of precipitation on the first day, P_n, and no precipitation from the second day, P_{n+1}, is included in the calculation of Q_{n+1}. Generally P_n refers to precipitation recorded between 08:00 hrs (day n) to 08:00 hrs (day n+1), and, with the time lag of 6 hours, it roughly corresponds to Q_{n+1}.

In large basins with multiple elevation zones, the time lag changes during the snowmelt season as a result of the changing spatial distribution of the snow cover with respect to the basin outlet. The ratio of inputs (or time lag correction factors) from the n and n+1 days used in Equation (6) would have to be changed accordingly, not only to account for different time lags for each zone, but also for how they change from the beginning to the end of the snowmelt season.

In order to obtain a more accurate split of the runoff from days n and n+1, Shafer, et al (Reference 12) recommend planimetering of the areas under the actual daily hydrographs to come

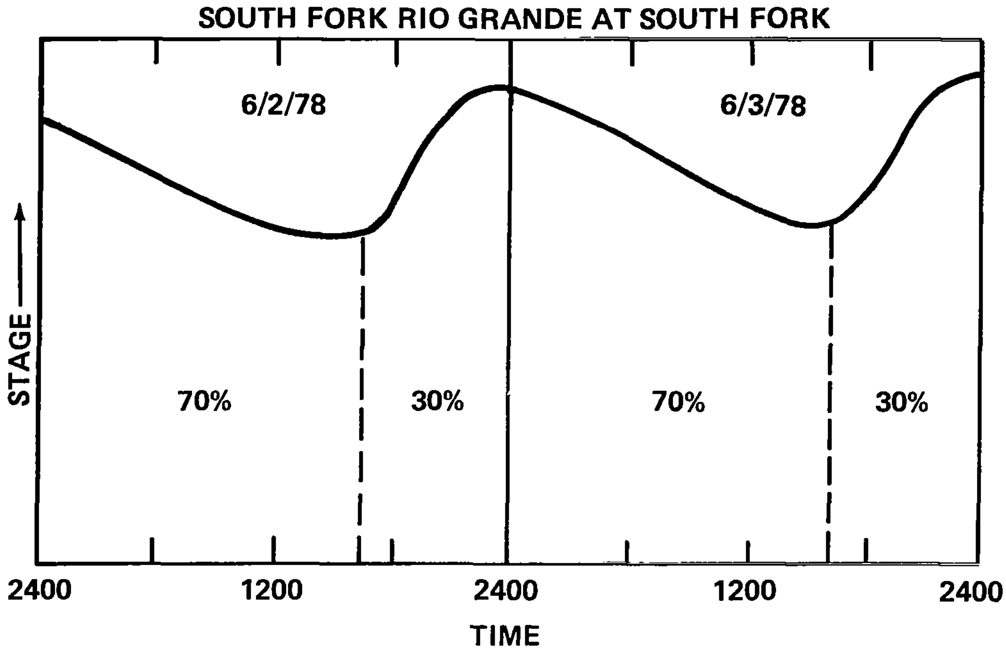


Figure 9. Planimetered hydrographs for determination of the time lag correction factors ($L_n = 0.7$, $L_{n+1} = 0.3$) for the South Fork basin in Colorado (from Reference 12).

up with the appropriate time lag correction factors (L) as shown in Figure 9. For some of the time lags encountered so far, the following L values may be utilized for determining the contributions to Q_{n+1}:

6 hours – $L_n = 0.5$, $L_{n+1} = 0.5$; 10 hours – $L_n = 0.7$, $L_{n+1} = 0.3$;

12 hours – $L_n = 0.75$, $L_{n+1} = 0.25$; 15 hours – $L_n = 0.8$, $L_{n+1} = 0.2$;

18 hours – $L_n = 1.0$, $L_{n+1} = 0.0$.

ASSESSMENT OF SIMULATION ACCURACY

One of the first steps to be followed in determining how well a model simulates actual flow conditions is a comparison plot of computed and measured hydrographs. Figure 10 illustrates this comparison for the South Fork basin in Colorado for the 1979 snowmelt season. In order to quantify the comparison, several goodness-of-fit measures may be added to the hydrograph plot. The computer program automatically calculates the percentage volume difference (D_V) between the measured (RO_M) and model-computed (RO_C) seasonal runoff as shown in Equation (16).

$$D_V = \frac{RO_M - RO_C}{RO_M} \cdot 100 \tag{16}$$

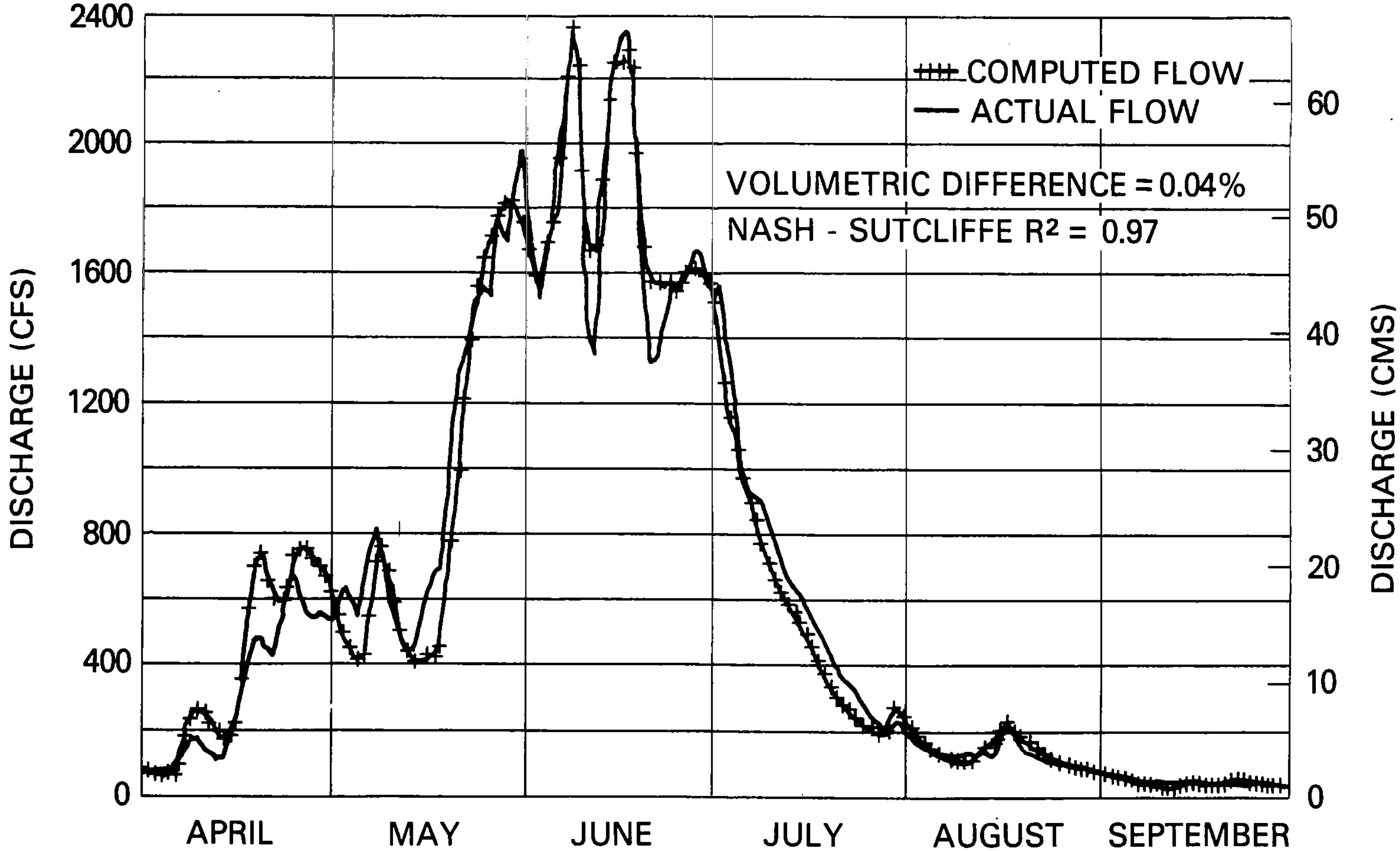


Figure 10. Simulated versus measured streamflow for the South Fork of the Rio Grande during the snowmelt season of 1979.

Model performance on a daily basis can be evaluated using the nondimensional Nash–Sutcliffe (Reference 16) R^2 value:

$$R^2 = 1 - \frac{\sum_{i=1}^{n} (q_i - q_i')^2}{\sum_{i=1}^{n} (q_i - \bar{q})^2} \tag{17}$$

where

R^2 is a measure of model efficiency
q_i = observed daily discharge
q_i' = simulated daily discharge
$\bar{q}$ = mean of observed discharge
n = number of daily discharge values.

The Nash–Sutcliffe R^2 value is analogous to the coefficient of determination and is a direct measure of the proportion of the variance of the recorded flows explained by the model (Reference 17). The SRM program also calculates and outputs this goodness-of-fit parameter to facilitate comparison of the correspondence of the daily flow values. Further examples of runoff simulation during snowmelt are given in Figures 11 and 12. Figure 13 shows a simulation extended to a whole year.

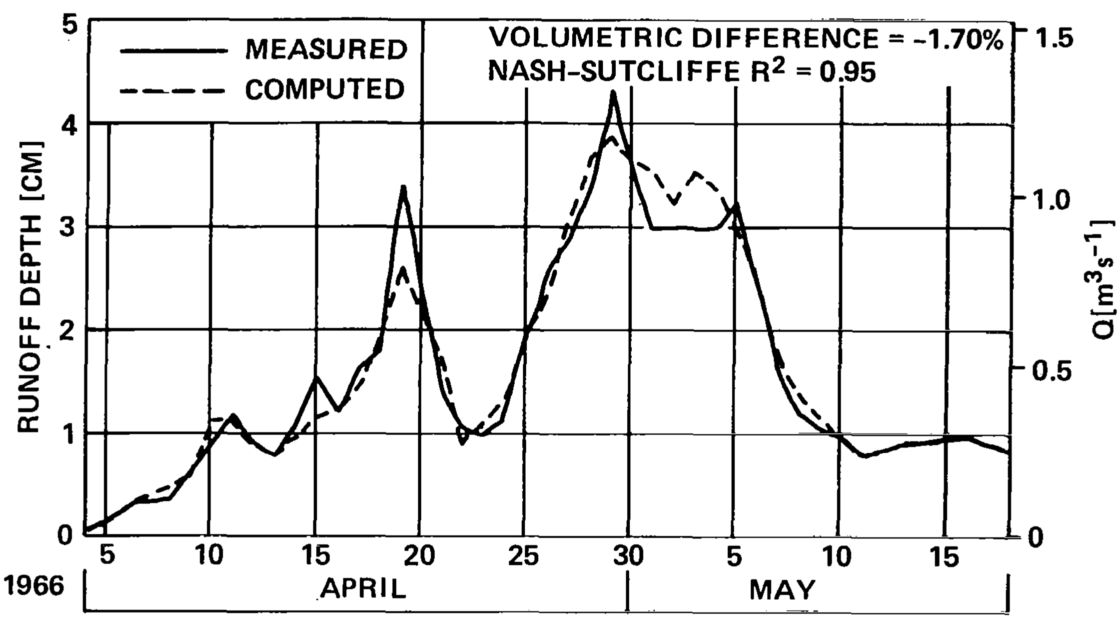


Figure 11. Snowmelt-runoff simulation for the basin Modrý Důl (2.65 km^2), Czechoslovakia.

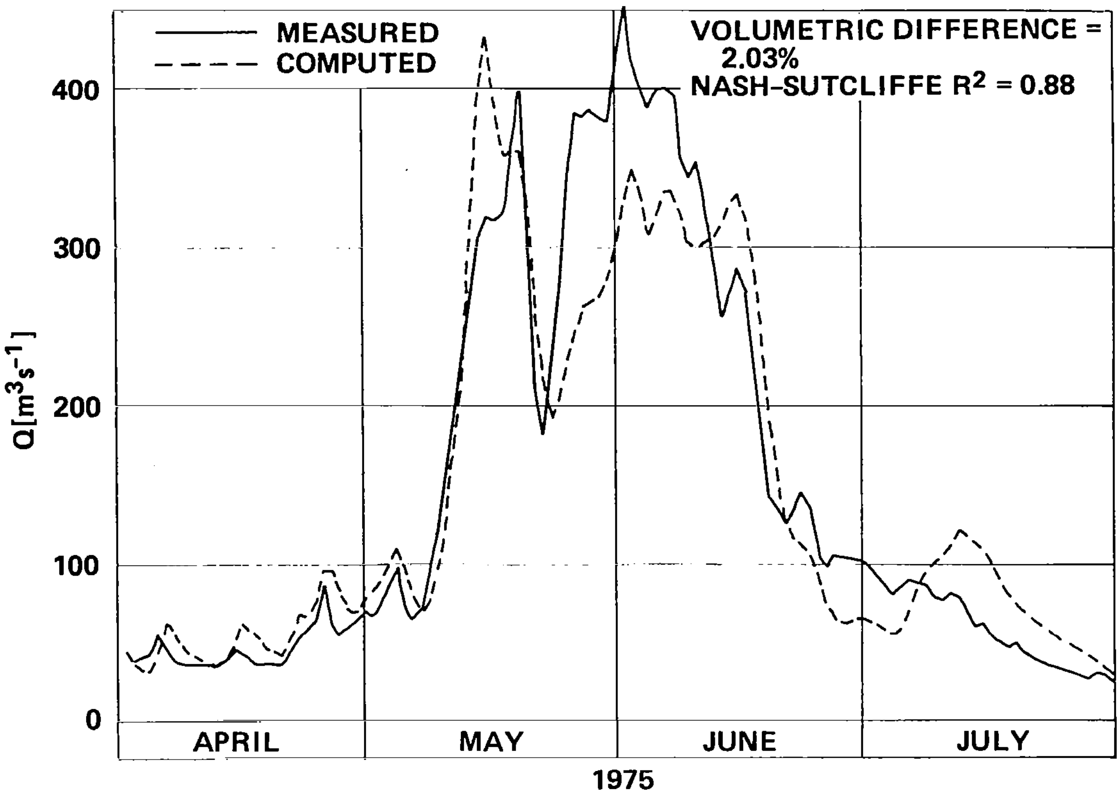


Figure 12. Snowmelt–runoff simulation for the Kings River basin (4000 km^2) in California, U.S.A. for 1975.

When running the model in the simulation mode, if a good agreement is not achieved initially, the following order of items to check in problem solving is recommended:

1. Re-evaluate the *snow cover depletion curves* to check that errors were not made in drawing the curves. This could result in a too high or too low computed runoff. One especially common error is the overlooking of a precipitation event occurring just before a satellite pass. The thin layer of transient snow cover that results causes an over estimation of the seasonal snow cover, S, which causes the depletion curve to be too high.

2. Reconsider the *lapse rate* used in the basin. Often times an average lapse rate may be too high or too low for a particular month resulting in the number of degree-days being too high or too low (especially for the upper elevations of the basin).

3. The *runoff coefficient* may require adjustment if the computed discharge is too high or too low. Typically, the runoff coefficient is the most difficult of the basin parameters to estimate accurately and should be examined closely after any gross errors due to discrepancies in snow cover and lapse rate have been ruled out.

4. The *degree-day factor* should be investigated after the runoff coefficient. Since the degree-day factor can be estimated initially from snow density measurements,

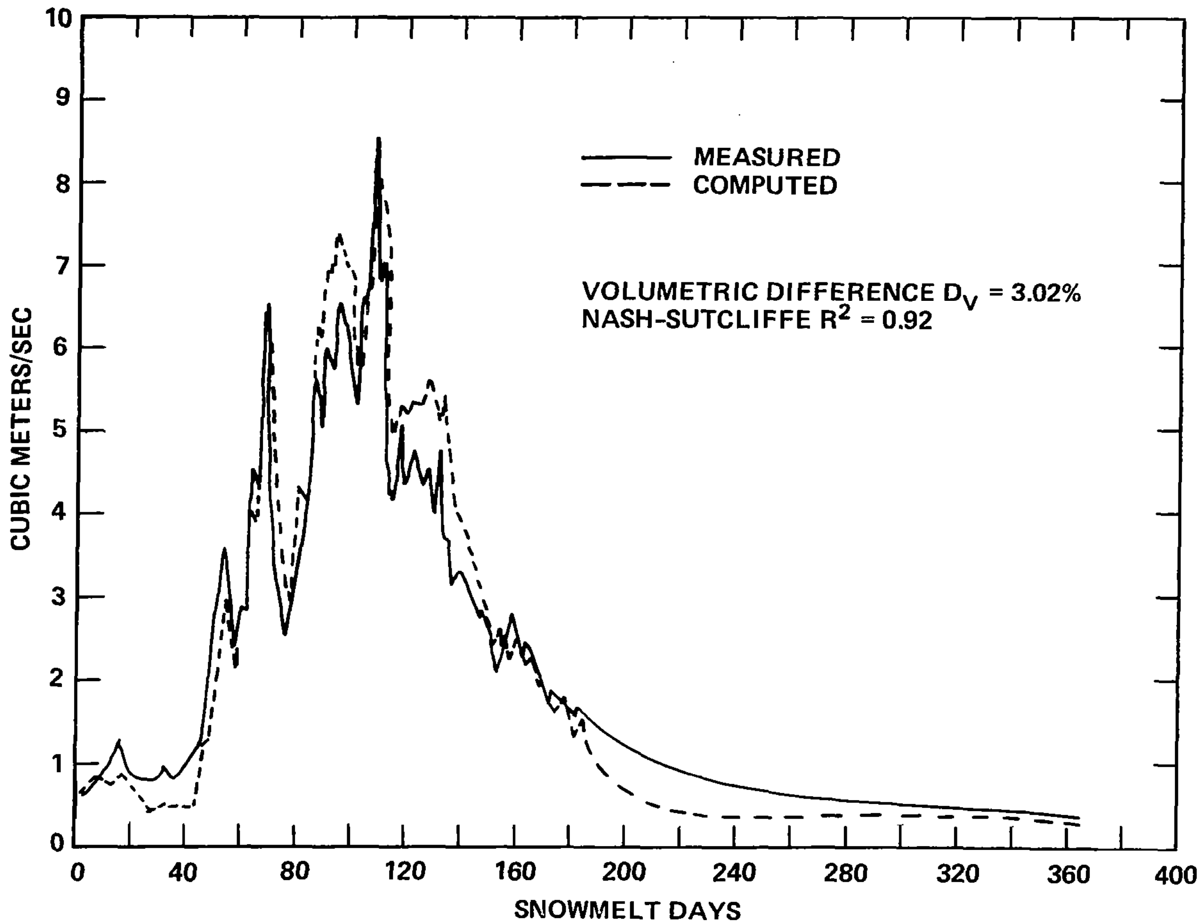


Figure 13. Simulated versus measured streamflow for the Dischma basin (43.3 km^2) for April 1974 – March 1975 (365 days).

less probability of error may be expected. If, however, good snow density values are not available, adjustment of the degree–day factor may be necessary to have some effect on the runoff volume. Unusually high wind conditions may also result in the need to temporarily increase the degree–day factor, whereas new snow falling on the seasonal snowpack may cause a temporary decrease in the degree–day factor.

5. Discrepancies in *precipitation* input to SRM may result in two kinds of error. Precipitation values that are too high or low may result in similar effects on computed runoff. More importantly, peak flows may be missed altogether if precipitation stations in the basin are not properly measuring local rainfall variations, especially in summer. Rainfall data from nearby stations and corrections for gauge catch deficit may have to be considered to improve the quality of data.

6. The *recession coefficient* should be revised if the model reacts too quickly or too slowly in comparison with the actual hydrograph. If the computed hydrograph generally rises or drops too rapidly, recession coefficients are too low, probably as a result of including non representative points in

evaluating Equation (6) (Figure 6). Consideration should be given to which points to include when drawing the line. In addition, if the lower envelope curve is being used, other curves such as the average or even the three-quarters line should be tested as alternatives. On the other hand, if the hydrograph rises or drops too slowly the recession coefficients are too high. This usually results from insufficient data available for high flows when deriving Equation (6).

7. Discrepancies in the timing of flow peaks and valleys can be due to an incorrectly determined *time lag*. Re-evaluation of the time lag is called for with special consideration given to a seasonal change in the discharge time lag as the snow cover retreats to higher elevations futher from the stream late in the snowmelt season. The model is setup to handle seasonal variations in the time lag.

OPERATION OF THE MODEL FOR REAL-TIME FORECASTS

A few modifications of the model are necessary to operate it in the forecast mode as opposed to operation in the simulation mode. Most important is acquisition of forecasts of the major input variables – temperature, precipitation, and snow cover – during the forecast period. The most difficult of these variables to forecast is precipitation. Generally, average daily values of precipitation or selected historical time series will have to be used. Temperature forecasts can be obtained for several days to one or two weeks. For longer durations, average values should be used and should be as good as forecasted values. The temperature forecasts are doubly important because of the effect of the temperature on the depletion of the snow cover.

The use of snow-cover depletion curves from prior years is not possible because the curves vary from year to year, and the actual curve for a given year is not known at the beginning of the snowmelt season. In order to forecast the snow-cover depletion, it is first necessary to modify the depletion curves by relating the snow coverage to accumulated degree-days instead of elapsed time.

When using standard depletion curves, which relate the precent of the basin or zone covered by snow to elapsed time during the snowmelt season, it isn't possible to detect extreme high or low accumulations of snow. In addition, a steep decrease of the snow-covered area in the standard depletion curve can reflect either a shallow snowpack or high melt rates. Conversely, a slow decrease results from either a deep snow cover or slow melt rates resulting from low temperatures. Such uncertainty can be eliminated using modified depletion curves that relate the snow-covered area to the accumulated number of degree-days.

Figure 14, 15, and 16 show such modified depletion curves derived for the years 1976, 1977, and 1979 for each elevation zone of the South Fork basin in Colorado. It is immediately evident that the same incremental number of degree-days results in a greater decrease in snow cover in 1977 than in 1979 as a result of the much below normal 1977 snowpack. Resulting runoff for the year 1976 falls between the high runoff year of 1979 and the record drought year of 1977 as do the modified depletion curves for 1976 in Figures 14, 15, and 16. In a future year, if a modified depletion curve in the first month of the snowmelt season takes a course similar to that of 1977, a small snow accumulation like 1977 is indicated. Similarly, large accumulations like 1979 and intermediate snow amounts like 1976 can be estimated from the course of the modified depletion curves in the initial stage of the snowmelt season. Note, however, that this technique for

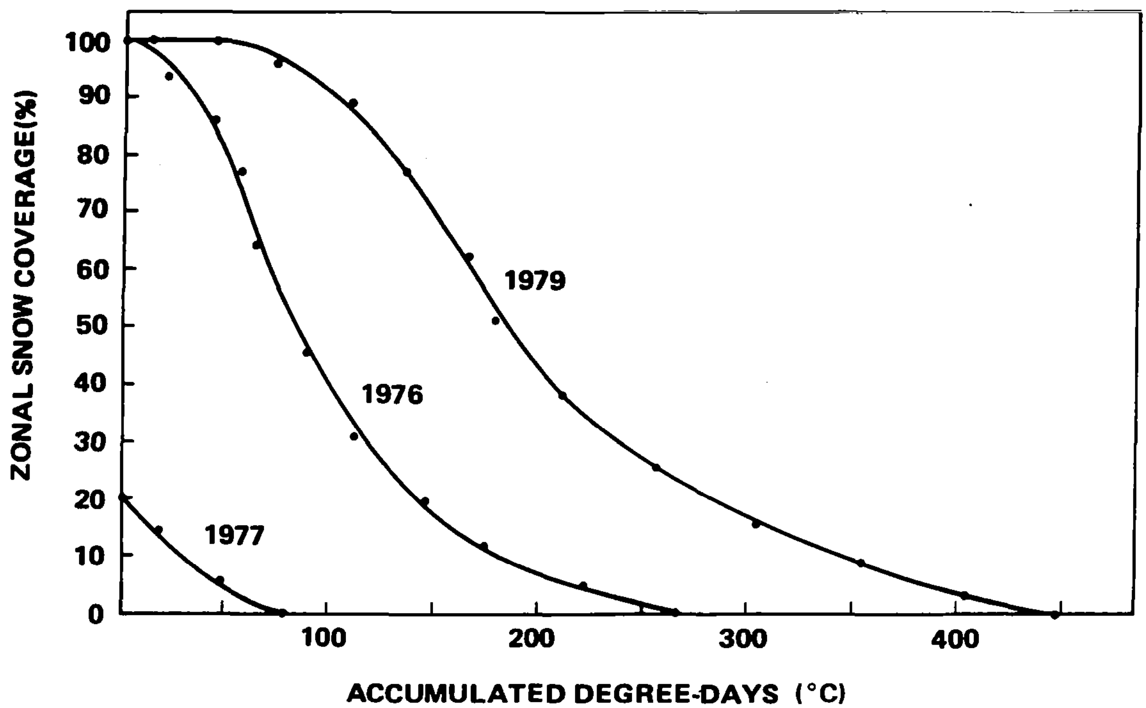


Figure 14. Depletion curves of snow coverage versus accumulated degree-days in elevation zone A of the South Fork basin in the years 1976, 1977, and 1979.

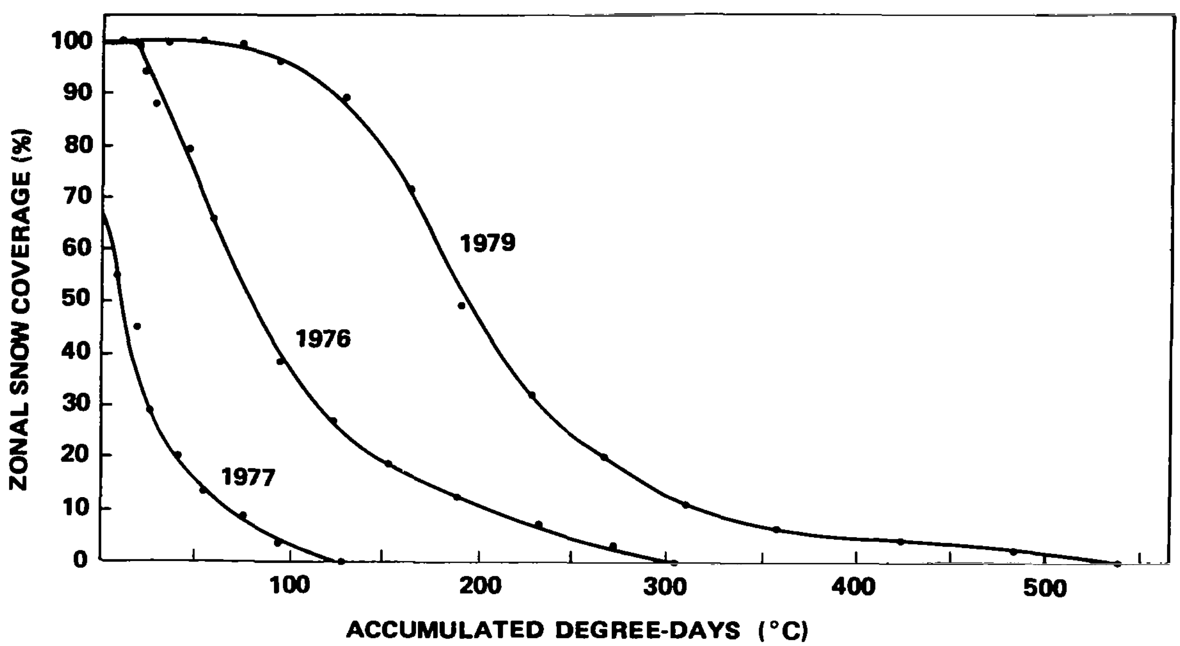


Figure 15. Depletion curves of snow coverage versus accumulated degree-days in elevation zone B of the South Fork basin in the years 1976, 1977, and 1979.

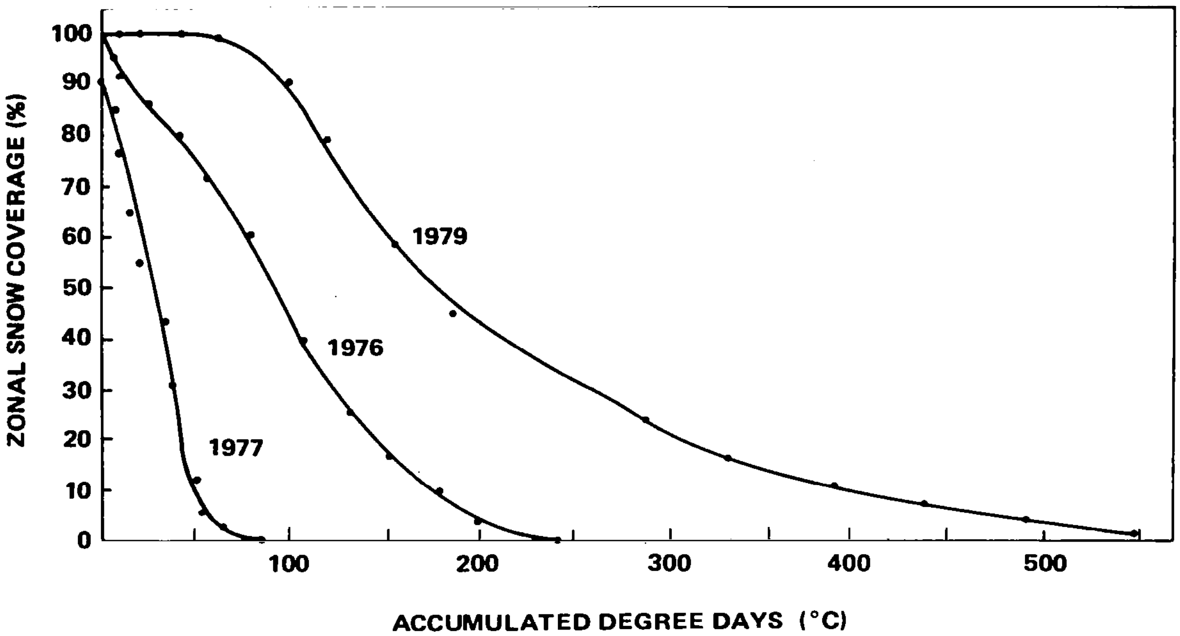


Figure 16. Depletion curves of snow coverage versus accumulated degree-days in elevation zone C of the South Fork basin in the years 1976, 1977 and 1979.

estimating relative snow accumulations is only valid for comparable precipitation amounts occurring during the snowmelt period. For example, exceptional spring and summer snowfalls can slow down the decrease of snow coverage even with a shallow initial snowpack.

To demonstrate the application of the method for operational purposes, assume that a forecast of the seasonal runoff volume is required on 1 April. The zonal snow-cover depletion curves for the snowmelt season are not yet known. As a result, an average snow accumulation must be assumed, and the corresponding modified depletion curves must be chosen. If conventional or automatically measured snow water equivalent values are available for the basin, a better estimate of the snow accumulation may be possible. In this case, a better choice of the appropriate modified depletion curve should result. After several weeks, the first evaluations of snow-covered area from satellite images can be related to the accumulated degree-days to determine whether the decrease of snow-covered area agrees with the initially chosen modified depletion curve. If the comparison is close, the snowmelt-model comparisons are continued until the disappearance of snow and the seasonal runoff volume is obtained as a total of the calculated daily flows. For these seasonal forecasts, the long-term average temperature for each day until the snow disappears can be used for the determination of the degree-day values. A further refinement would be the forecasting of short-term snowmelt runoff. This type of improvement would require the daily forecasts of temperature during the forecast period as previously mentioned.

If the decrease of snow-covered area has not occurred at the rate initially assumed on 1 April, e.g., it is considerably slower than indicated by the assumed modified depletion curve, a greater accumulation of snow for the basin is indicated. Consequently, the initial modified depletion curve is rejected, and an updated forecast of the runoff volume is made by using the curve valid for a large accumulation of snow. The better the original estimate of snow accumulation, the less the original seasonal forecast will have to be modified. When several years of snow accumulation, satellite snow cover, and snowmelt-runoff data are available, a nomograph of modified depletion curves will be possible, with the appropriate depletion curve chosen by average snow water equivalent rather than similarity to some prior year as shown in Figure 17.

Figure 18 shows a modified depletion curve on the left that has hypothetically been selected based on the best knowledge available from snow accumulation data. If a discharge forecast is to be issued, for example, on May 15 for the following week, the depletion curve is extrapolated as follows. The snow coverage is, as shown in Figure 18, 80%. If 30 degree-days are forecasted for the next week, a drop in snow cover to 40% results, and the "normal" depletion curve is extrapolated as shown on the right side of Figure 18. Forecasted temperatures and extrapolated snow-covered areas are used to compute the meltwater production. If the forecast gives temperatures below the freezing point, the snow coverage will remain at 80% and no snowmelt will result.

In an operational situation, it is not necessary to continuously run the model with calculated streamflow as input data. SRM has the provision which allows updating with actual streamflow information every seven days. The use of real data for such updates will improve the accuracy of the forecasts.

Figure 19a shows a model runoff simulation for the Dinwoody Creek basin in Wyoming that had a measured discharge twice as high as the computed value on August 1. Updating the model with the actual discharge on August 1 improves the simulation as shown in Figure 19b. Even without updating, however, the initial discrepancy is soon eliminated automatically. This self-adjusting feature depends on careful assessment of Equation (6).

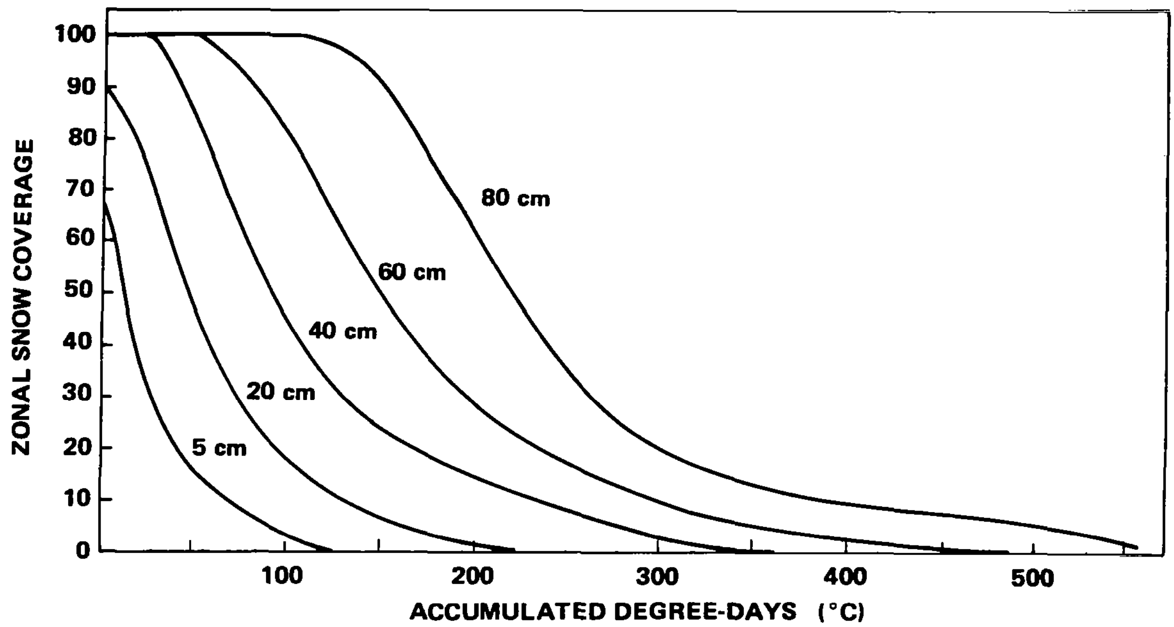


Figure 17. Nomograph for selection of modified depletion curve in zone B of the South Fork basin using estimated snow water equivalent (in cm) as the criterion.

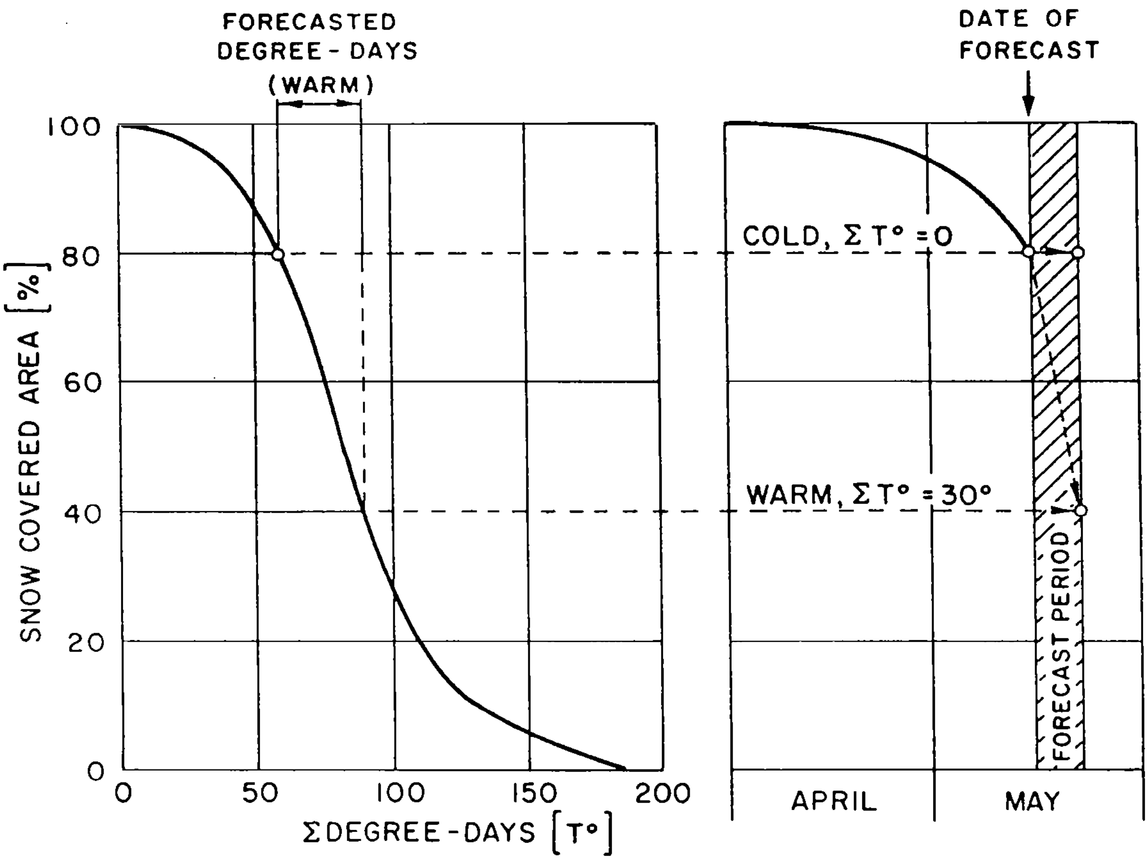
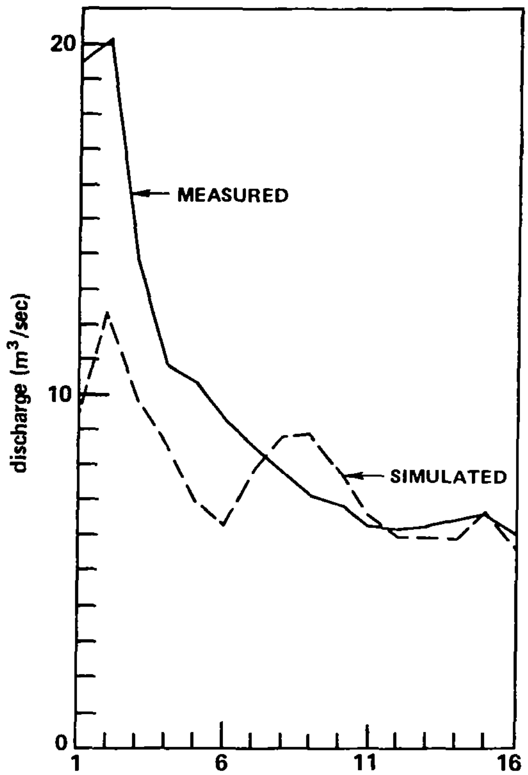


Figure 18. Graphical extrapolation of depletion curves of snow coverage using forecasted degree–days.

NECESSARY COMPUTING FACILITIES

For use of SRM in situations where manpower is not limited but computing resources may be, any pocket calculator with the function x^y is sufficient for day-to-day computation of the discharge. The pocket calculator can also be used in the same way for limited day-to-day forecasts of discharge. In addition, in the initial stages of setting up the computer program to run SRM, the pocket calculator can be indispensible in the checking of computations. The fact that the basic form of SRM (Equation 1) is relatively simple, which permits use of the now widely available pocket calculator, also opens the possibility that the model may be run in the field or at local offices as opposed to only at central computing facilities. Such flexibility increases the chances that SRM can be used in operational situations.

In utilizing the model, it is naturally more convenient to use a computer program (and a computer), an example of which is described in the following section. The use of the computer approach provides a great savings in time which is especially important for calculations of extended periods, such as the snowmelt runoff season or even a year. In addition, the computer program can easily handle many complicated calculations which become extremely tedious on a pocket calculator. Examples of this involve the different handling of precipitation depending on the form (rain vs. snow), the introduction of different time lags for different elevation zones, and the use of multiple climatic stations.



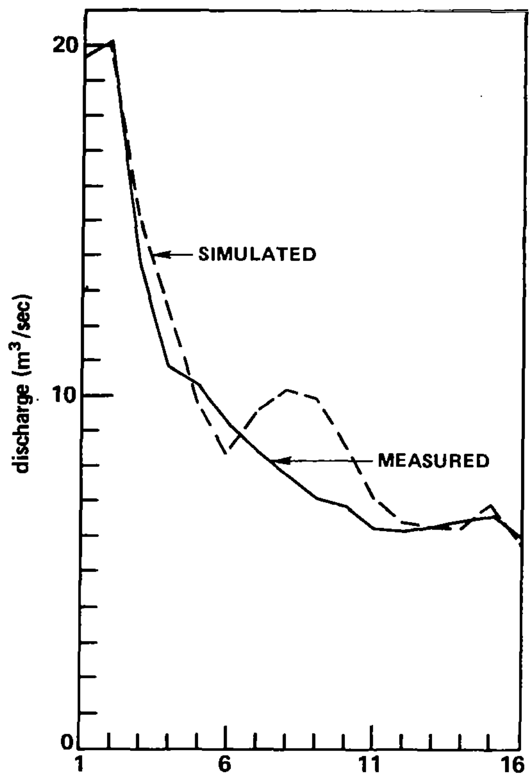


Figure 19. Discharge simulation in the Dinwoody Creek basin a) without updating and b) with updating with actual discharge on 1 August.

SRM is more flexible in its applications when the computerized approach is used. Several computer runs may be made in a short time period in order to demonstrate the effect of hypothetical changes of temperature on the resulting runoff in any desired number of variations.

In general, however, SRM does not require numerous runs because calibration is not necessary. The ease with which computer runs for various sets of parameters can be obtained should not lead to a replacement of the deterministic approach of the model by a "try and see" philosophy. The model is designed to operate with physically-based estimates of basin parameters which should not require much change after their initial selection. Inclusion of a self-calibrating routine might improve the accuracy of simulations, however, it would limit the use of the model to basins with historical data necessary for such optimizing. Also it would deprive the user of the possibility to detect errors in data sets.

The SRM computer program presented in this manual has been designed to operate on an IBM 3081 available at Goddard Space Flight Center (GSFC). However, the SRM program can execute on any 32-bit IBM computer using FORTRAN IV. The program can run on any minicomputer that utilizes FORTRAN IV with the NAMELIST feature, with minimum revisions (such as variable type declarations). Some versions of FORTRAN on some computers do not support the NAMELIST input of data, particularly the DEC PDP FORTRAN or PDP FORTRAN-FOUR-PLUS. Consequently, major revisions would have to be made in subroutine READIN to read input data as formatted input. No changes, however, would have to be made in the program computations.

Some computers may have peripheral output devices that are not in 132-character length. If so, then some modifications would have to be made in the formatting of output data. Since formatting of output data is provided as an option in the program, the user may not want to exercise that option and simply print out the statistics (such as goodness of fit, etc.).

In order to execute the program on much smaller computers, such as microprocessors where execution time and core storage is limited, some major modifications would have to be made. All formatted output options can be eliminated, except for output statistics. The number of elevation zones can be cut down to reduce the size of the input arrays. The capability to process input temperatures can be eliminated, thus eliminating some input arrays. The user would have to provide input temperatures in degree-days and per zone, or at least provide a pre-determined lapse rate to extrapolate temperatures in degree-days to each elevation zone.

Presently, the SRM program can be run for a snowmelt season of variable length, and it can also be operated in both snowmelt and non-snowmelt situations for up to 366 days. Up to eight basin elevation zones can be accommodated. For a six-month snowmelt season, the computer requirements to execute the program on the GSFC IBM 3081 are as follows: CPU time = 3 sec.; I/O time = 35.4 sec. Total core requirements for compilation, linkage and loading of input data sets, producing printer plots and input temperature processing amount to approximately 170 K bytes of core.

COMPUTER PROGRAM

The SRM program has been implemented on the IBM 3081 at NASA's Goddard Space Flight Center in Greenbelt, Maryland and written in the FORTRAN IV language. The general block diagram for the SRM computer program is shown in Figure 20. A more detailed functional flow diagram is shown in Figure 21 with indications of inputs required, computations, and output products. The detailed program flow chart used in writing the program is shown in Appendix A. The FORTRAN IV source listing for the SRM program and compilation on the IBM 3081 at Goddard Space Flight Center is shown in Appendix B.

The SRM program can be executed using a batch job stream submitted via cards or via a cathode ray tube (CRT) terminal depending on the computer system configuration available as shown in Figure 22. If the user system maintains a time sharing system like the Time Sharing Option (TSO) on the IBM 3081, the user can interactively modify input parameters via a CRT provided the NAMELIST data can be stored on permanent disk files. If only batch job processing via cards is available, the user can manually modify the input card deck.

User control of output from the SRM program is by input program options. Plots of actual and predicted stream runoff are available as an option provided the FORTRAN PRPLOT software supplied in Appendix B is compiled with the SRM program and the user system facilities are capable of producing printer plots. All input data may be reproduced as output during each computer run as an option. Statistical parameters such as the Nash-Sutcliffe goodness-of-fit measure and percent seasonal differences are output automatically, provided that actual streamflow data are available.

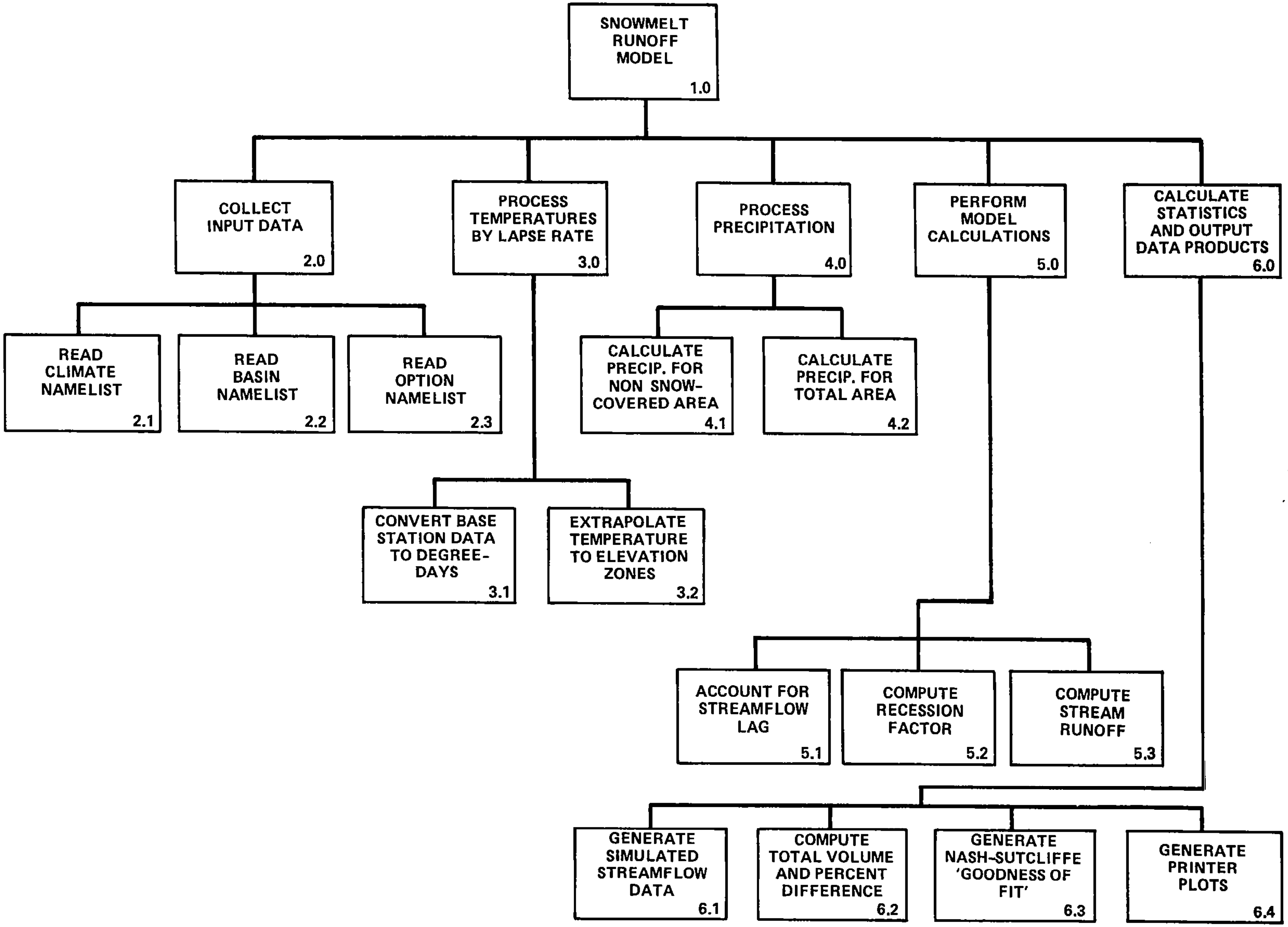


Figure 20. Functional flow chart of the snowmelt–runoff model computer program.

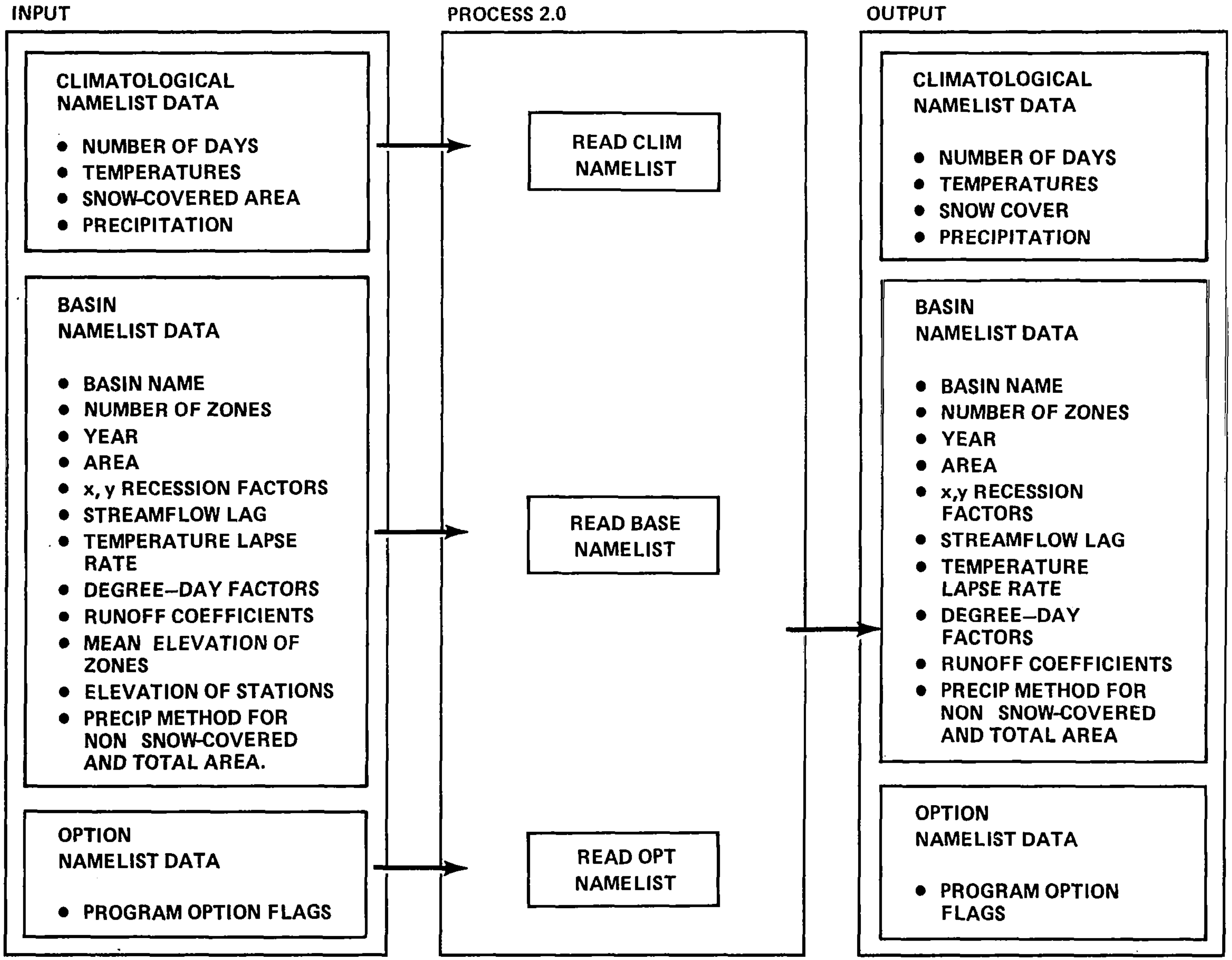


Figure 21a. Process-oriented flow chart of the computer program (reference 2.0 Collect Input Data in Figure 20).

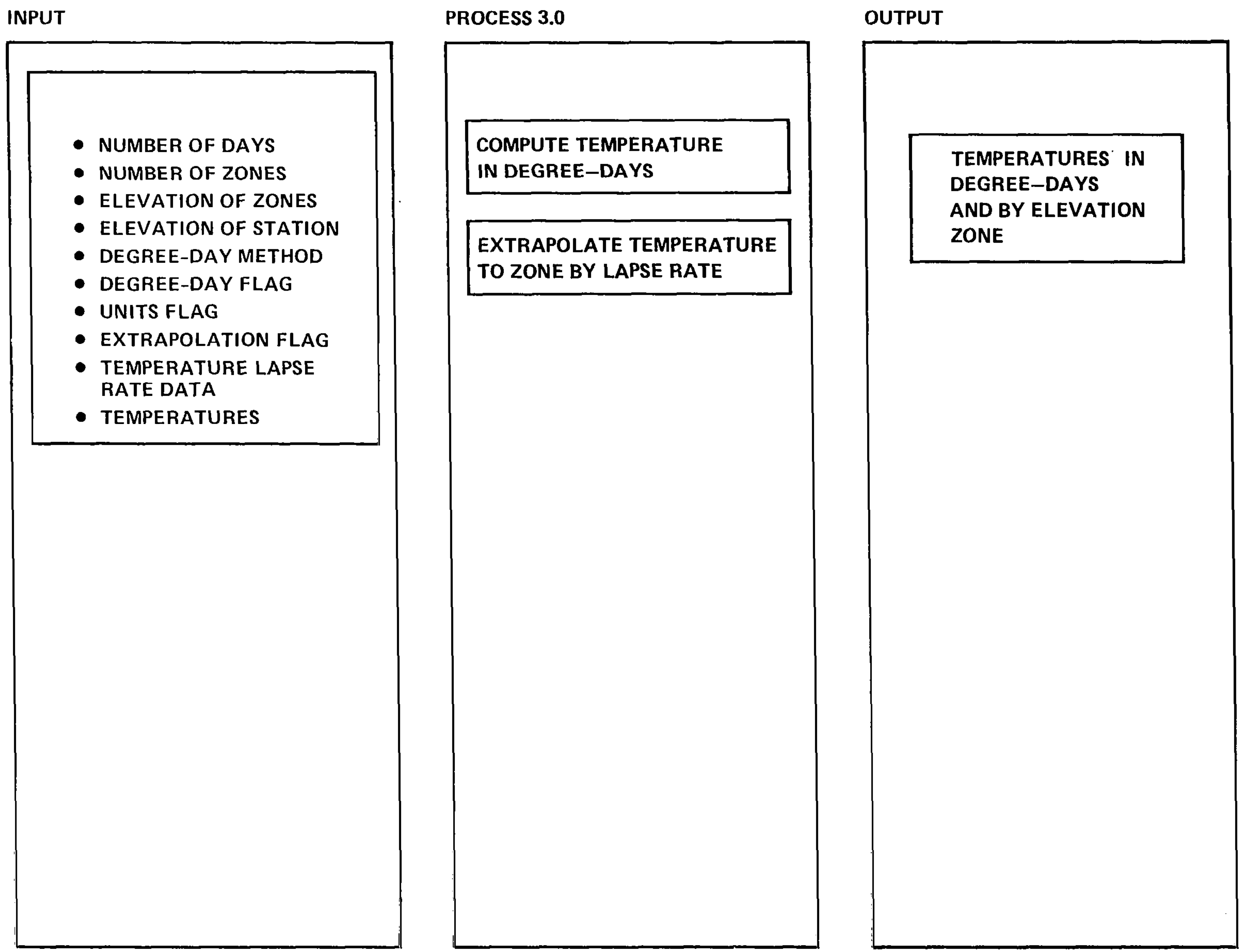


Figure 21b. Process-oriented flow chart of the computer program (reference 3.0 Process Temperatures by Lapse Rate in Figure 20).

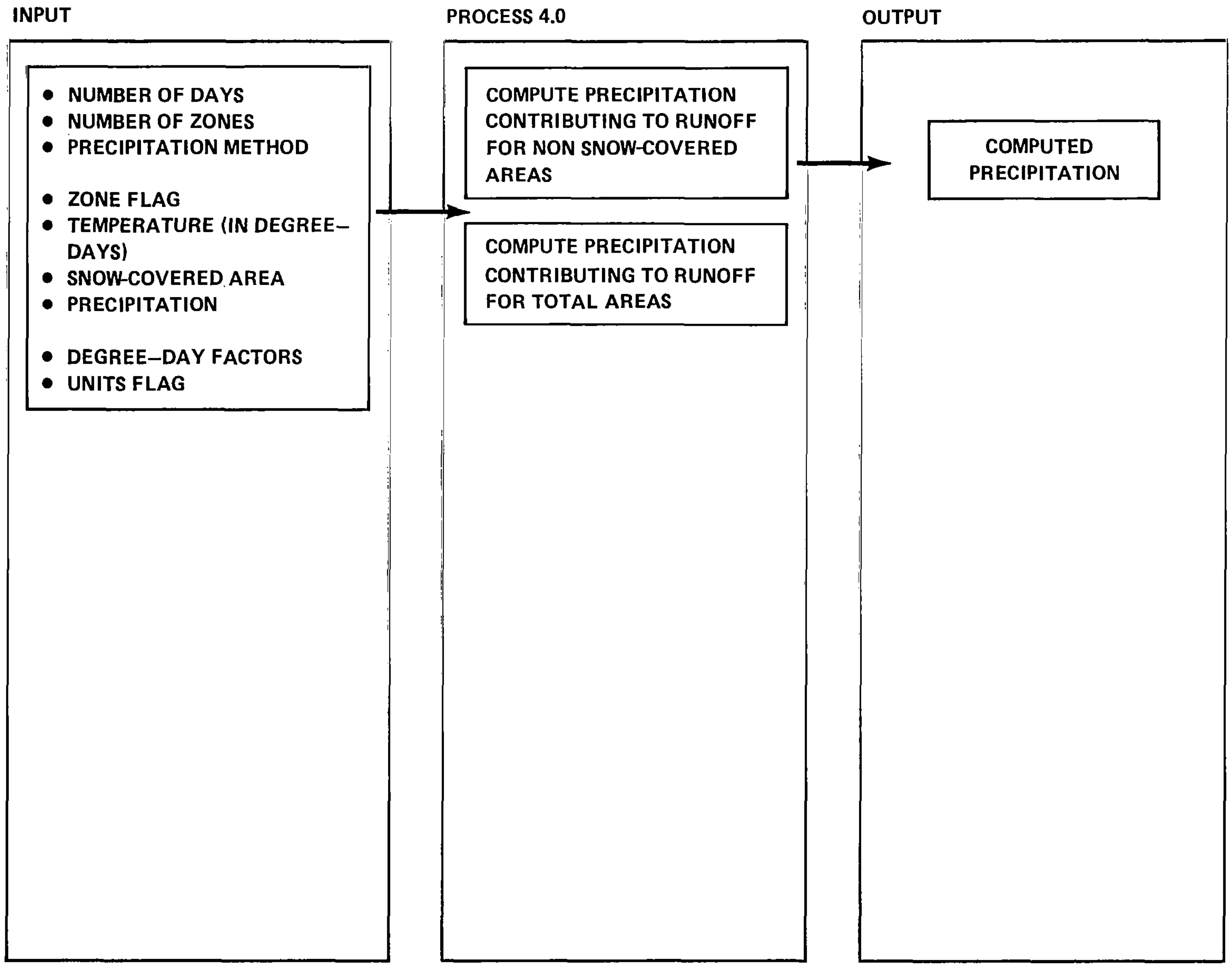


Figure 21c. Process-oriented flow chart of the computer program (reference 4.0 Process Precipitation in Figure 20).

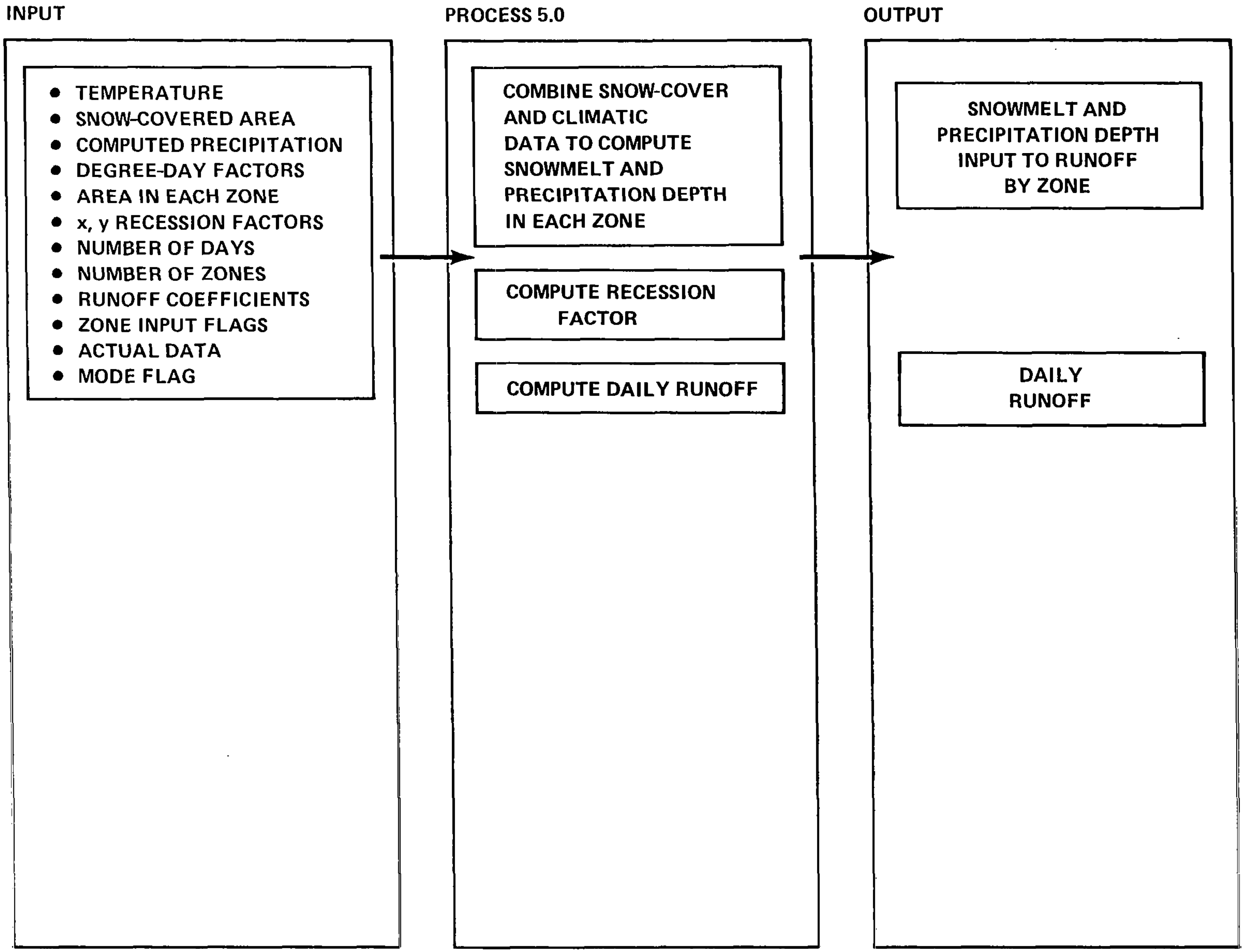


Figure 21d. Process–oriented flow chart of the computer program (reference 5.0 Perform Model Calculations in Figure 20).

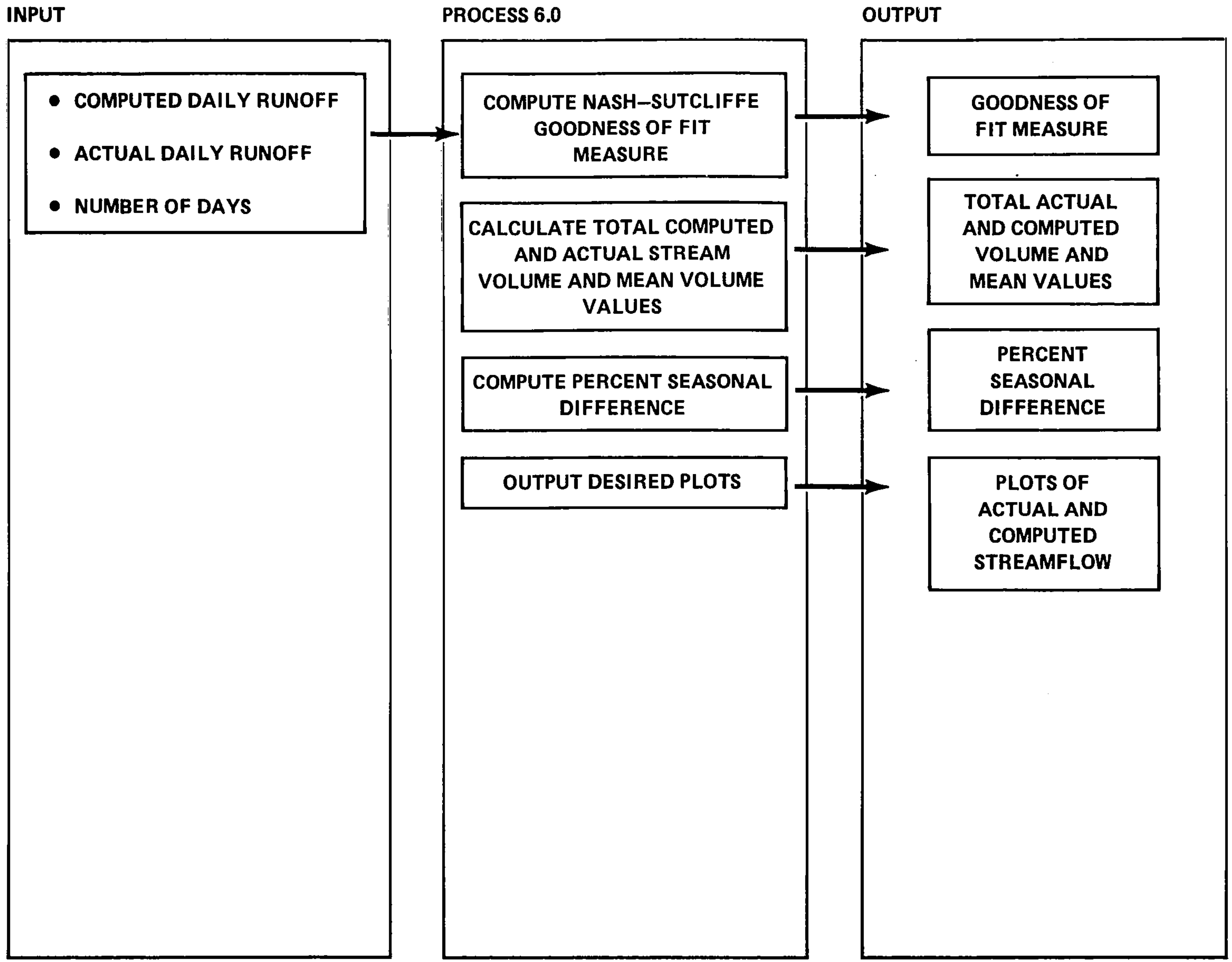


Figure 21e. Process–oriented flow chart of the computer program (reference 6.0 Calculate Statistics and Output Data Products in Figure 20).

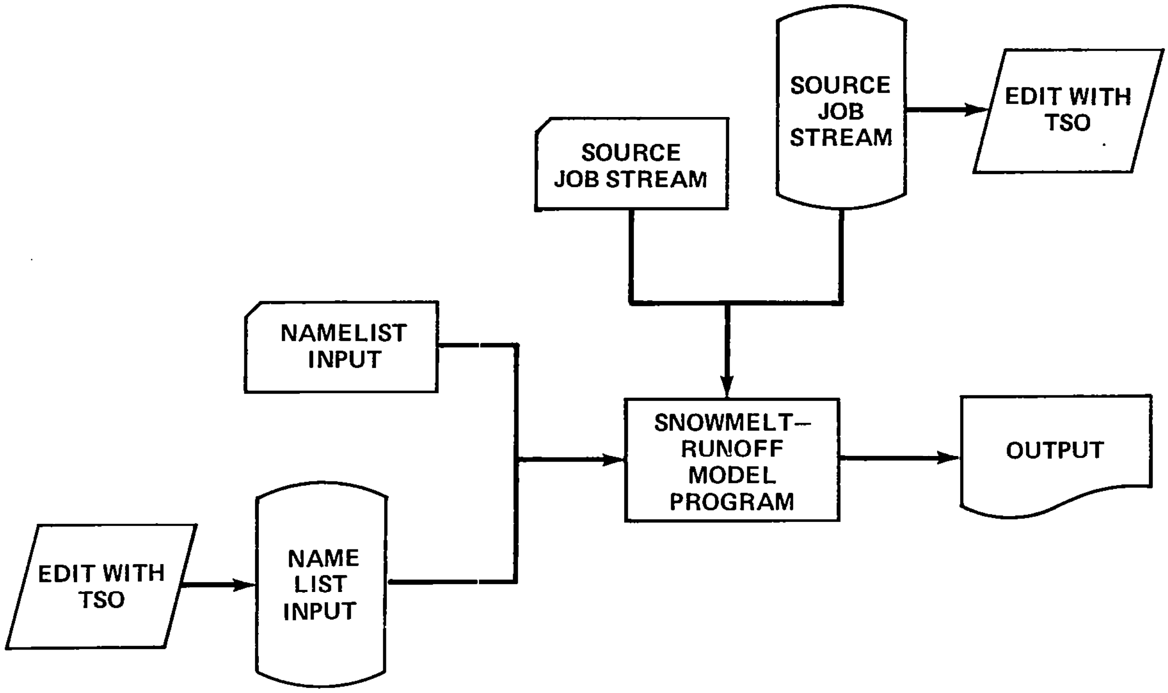


Figure 22. User perspective of snowmelt-runoff model program.

Program Input Requirements

In order to operate the SRM program, precipitation (PRECIP), temperature (T), and snow-covered area (S) must be evaluated on a daily basis (computer symbols for variables and parameters may differ from prior formulation symbols but can usually be recognized by all upper case letters). At the beginning of each computer run, the length of the simulation period in number of days (ND) must be designated (from 1 to 366). If the basin has a large elevation range, the total area must be divided into elevation zones as indicated previously. The total number of elevation zones (NZ) and the area of each zone (AREA) must be input to the program. The program has the capability for handling a total of eight elevation zones, if necessary.

Certain parameters for a specific basin must be evaluated for input to the model:

1. The adjustment by temperature lapse rate (ΔT in Equation 1 and DTLR in the computer program) determined every 15 days, if necessary, and for each elevation zone.

2. The degree day factors (a in Equation 1 and AN in the computer program) determined every 15 days.

3. The runoff coefficients (c in Equation 1 and CS or CR in the computer program) determined every 15 days.

4. The recession coefficient factors (x and y in Equation (6) and X and Y in the computer program, respectively). The recession coefficient, k, changes daily because of the changing discharge, Q, however, the constants x and y are derived one time for the given basin.

5. The percentage of the previous day's snowmelt appearing as runoff at the streamgage, PDR.

Namelist Parameters

Data to be input to SRM will be handled through the FORTRAN NAMELIST feature. The NAMELISTs CLIM and BASE provide climatological and basin dependent parameters, respectively, whereas the NAMELIST OPT provides program control options to properly execute the SRM program. Use of the NAMELIST feature results in some specific requirements:

1. Column 1 of each card image must be blank,

2. In Column 2, the first card image must contain &CLIM, &BASE, or &OPT.

3. Data items must be separated by a comma.

4. The last item in the last card image must be &END.

Despite these requirements NAMELIST input is easier for the user than formatted input because placement of data in specific card columns is not necessary.

The NAMELIST CLIM contains climatological snowmelt-runoff parameters for a particular basin and is read in only once per snowmelt-runoff computer run. A description of each climatological NAMELIST parameter, including, type, symbol and units are provided in Table 2. Temperature (T) and precipitation (PRECIP) data are not required to be input by elevation zone but can be extrapolated to the elevation zone from the base station readings in the program. Snow-covered area (S) must be input by elevation zone. In order for the SRM program to operate correctly, daily temperature values must be in degree-days for each elevation zone. Temperatures may be input as measured average daily temperatures or as maximum (TMAX) and minimum (TMIN) values and, through application of the temperature lapse rate, be extrapolated to the appropriate elevation zone. Temperatures can also be input already calculated in degree-days where no extrapolation is necessary. All of the parameters in the climatological NAMELIST CLIM must be provided. If no actual streamflow data are available, the user should provide an estimated value for the ACTUAL parameter on day 1 of the snowmelt-runoff period. Figure 23 shows typical climatological NAMELIST input for a study basin in Switzerland.

The NAMELIST BASE contains basin dependent SRM parameters and can be read in several times allowing the user the capability of making several computer runs without having to read in all of the climatological NAMELIST parameters. A description of each basin NAMELIST parameter including type, symbol and units are provided in Table 3. In order to execute the SRM program certain minimal basin NAMELIST input is required. These parameters include:

1. Identifying Information
   BASIN, NZ, IYEAR
2. Snowmelt-Runoff Model parameters
   AREA, X, Y, PDR, DTLR, AN, CS, CR, IPR

Table 2. Description of Variables in NAMELIST CLIM

Variable	Symbol*	Type	Units Metric	Units English	Description
ND	n	I*4	days	days	Number of snowmelt days
T	T_n	R*4	°C-day	°F-day	Temperature in degree-days
S	S_{zn}	R*4	%	%	Snow-cover area in each zone (100% = 1.0)
ACTUAL	Q_n	R*4	m^3s^{-1}	ft^3s^{-1}	Actual stream runoff
PRECIP	—	R*4	cm	in	Precipitation at base station
TMAX	—	R*4	°C	°F	Maximum daily temperature
TMIN	—	R*4	°C	°F	Minimum daily temperature
TCRIT	T_{CRIT}	R*4	°C	°F	Critical temperature to determine if precipitation is rain or snow.

*Note: The subscript n refers to number of snowmelt days; zn refers to number of snowmelt days per zone.

```
$CLIM
 ND=365,
 S=.88, .88, 4*.875, .87, .87, .865, .865, .865, .86, .86, .855,
   .85, .85, .845, .84, .835, .835, .83, .83, .825, .825, .82, .82,
   .815, .81, .805, .80,
   .80, .795, .795, .79, .785, .78, .775, .77, .765, .76, .76, .755,
   .745, .735, .725, .717, .70, .68, .66, .64, .60, .56, .52, .48,
   .44, .40, .37, .34, .31, .28, .25,
   .23, .215, .20, .185, .179, .17, .16, .15, .14, .135, .125, .115,
   .11, .105, .10, .095, .090, .085, .08, .075, .07, .065, .06, .055,
   .05, .045, .04, .035, .035, .03,
   .03, .025, .025, .02, .0183, .015, .01, .005, 23*0.,
   31*0., 91*0.,121*1.0,0.,
   5*.93, 5*.925, 5*.92, 5*.915, 5*.91, 3*.905, .90, .90,
   5*.90, 3*.895, .89, .89, .885, .885, 3*.88, .877, .875, .87, .865,
   .86, .855, .85, .845, .84, .835, .83, .825, .82, .815, .81, .80,
   .80, .795, .79, .785, .776, .77, .77, .75, .74, .735, .725, .715,
   .705, .695, .685, .67, .66, .65, .64, .63, .62, .61, .60, .59,
   .58, .565, .55, .54, .53, .52,
   .51, .50, .49, .48, .464, .45, .44, .43, .415, .40, .385, .37,
   .36, .35, .34, .33, .32, .305, .29, .28, .27, .26, .245, .23, .22,
   .21, .195, .18, .17, .16, .155,
   .15, .145, .14, .13, .115, .11, .105, .10, .095, .085, .08, .075,
   .0665, .05, .045, .04, .035, .03, .025, .02, .015, .01, .01, .05,
   7*0., 91*0.,121*.95,0.,
   .85, .845, .845, .84, .84, .835, .835, .83, .83, .83, .825, .825,
   3*.82, .815, .815, 3*.81, 10*.805,
   15*.805, .804, 9*.80, 5*.795, .79,
   4*.79, .786, 3*.785, 3*.78, 18*.785, .79,
   3*.79, .795,.797, .795, .79, .785, .78, .775, .77, .76, .75, .74, .73,
   .72, .71, .70, .69, .675, .66, .645, .63, .615, .60, .585, .57,
   .56, .55, .54, .53,
   .52, .51, .50, .49, .48, .47, .46, .45, .44, .435, .43, .42, .413,
   .40, .385, .38, .37, .36, .35, .345, .34, .33, .32, .31, .30, .29,
   .28, .27, .26, .255, .25, 91*.25,121*.90,0.,
  ACTUAL=.60, .63, .67, .71, .76, .75, .80, .84, .89, .95, .96, .99,
          1.07, 1.23, 1.16, 1.01, .92, .85, .81, .79, .77, .77, .78,
          .80, .76, .75, .74, .74, .80, .84,
          .80, .76, .76, .77, .77, .76, .79, .87, .97, 1.10, 1.14, 1.12,
         1.23, 1.47, 1.55, 1.85, 2.20, 2.48, 2.84, 2.93, 3.03, 3.51,
         3.27, 2.72, 2.46, 2.40, 2.63, 2.83, 2.70, 3.04, 4.05,
         4.51, 3.78, 4.02, 4.85, 5.83, 6.33, 4.92, 3.99, 3.63, 3.26, 2.92,
         2.67, 2.43, 2.54, 2.84, 2.93, 3.17, 3.67, 3.41, 3.57, 4.11, 5.44,
         5.28, 5.59, 4.81, 5.01, 6.10, 5.61, 5.93, 5.61,
         5.62, 6.68, 6.55, 6.23, 6.06, 6.18, 6.20, 5.29, 5.21, 6.61, 6.52,
         6.65, 6.84, 7.86, 8.72, 6.60, 7.16, 7.14, 5.34, 4.54, 4.48, 4.12,
         4.06, 4.15, 5.08, 4.16, 4.31, 4.53, 4.39, 4.44, 4.81,
         4.48, 4.23, 4.42, 4.32, 4.60, 4.04, 3.81, 4.70, 4.03, 3.60, 3.54,
         3.24, 3.09, 3.11, 3.18, 3.24, 3.25, 3.17, 3.12, 2.99, 2.90, 2.83,
         2.79, 2.67, 2.99, 2.55, 2.52, 2.45, 2.25, 2.13, 2.08,
        2.57, 2.16, 2.16, 2.94, 2.38, 2.43, 2.52, 2.27, 2.17, 2.37, 2.19,
        2.08, 2.02, 1.97, 1.93, 1.90, 1.82, 1.75, 1.72, 1.78, 1.73, 1.64,
        1.58, 1.59, 1.55, 1.53, 1.52, 1.58, 1.61, 1.52,
        1.52, 1.47, 1.41, 1.43, 1.39, 1.35, 1.30, 1.33, 1.29, 1.26, 1.23,
        1.21, 1.15, 1.13, 1.11, 1.08, 1.07, 1.04, 2*1.03, 1.01, 0.99, 0.98,
        0.96, 0.95, 0.94, 0.94, 0.93, 0.93, 0.91, 0.89,
        0.88, 0.87, 0.86, 0.86, 0.84, 0.83, 0.82, 0.84, 0.81, 0.81, 0.78,
        0.78, 0.78, 0.77, 0.76, 0.77, 0.77, 0.75, 0.77, 0.75, 0.74, 0.73,
        0.72, 0.71, 0.71, 0.70, 0.71, 0.70, 0.71, 0.69,
        0.69, 0.69, 0.67, 0.67, 0.67, 0.67, 0.66, 0.66, 0.65, 0.65, 0.64,
        0.63, 0.62, 0.60, 0.63, 0.63, 0.62, 0.61, 0.60, 0.59, 0.59, 0.57,
        0.57, 0.56, 0.56, 0.56, 0.55, 0.55, 0.56, 0.52, 0.54,
        0.56, 0.53, 0.52, 0.51, 0.51, 0.50, 0.50, 0.50, 0.50, 0.50, 0.50,
       0.49, 0.49, 0.48, 0.47, 0.48, 0.49, 0.49, 0.48, 0.47, 0.47, 0.47,
       0.46, 0.46, 0.46, 0.45, 0.45, 0.45, 0.45, 0.44, 0.44,
       0.44, 0.44, 0.44, 0.44, 0.44, 0.44, 0.43, 0.42, 0.42, 0.42, 0.42,
       0.42, 0.42, 0.41, 0.41, 0.40, 0.40, 0.40, 0.40, 0.40, 0.40, 0.39,
       0.39, 0.39, 0.39, 0.39, 0.39, 0.39,
       0.39, 0.38, 0.39, 0.39, 0.38, 0.38, 0.38, 0.37, 0.37, 0.37, 0.37,
       0.37, 0.37, 0.37, 0.37, 0.36, 0.34, 0.36, 0.36, 0.36, 0.36, 0.35,
       0.36, 0.36, 0.35, 0.35, 0.34, 0.34, 0.34, 0.34, 0.34,
```

Figure 23. Sample NAMELIST CLIM input for the Dischma basin, 1974.

```
PRECIP=.19, .06, 0.00, 0.00, .04, .34, 0.00, .01, 5*0.00, .10,
     .03, .53,  .13,  .07, .02, 0.0, 0.00, .03, 0.00, .26, .59,
     .31, .02, 0.00, .02, .13,
     .21, .22, .03, 0.00, .45, .84, .09, .01, 0.00, 0.00, .27,
     .98, 0.00, .02, .27, 5*0.00, .26, 0.00, 3.23, .48, .38, .03,
    0.00, .52, .97, 0.00, .02,
    1.49, 4*0.00, .37, .02, .06, .07, .41, .85, 1.06, 1.72, .03,
    0.00, .66, 0.00, .70, 1.20, 0.00, 0.00, 1.41, .65, 1.59, .09,
    0.00, 2.71, .83, 1.33, 1.82,
    0.00, .57, 0.00, .89, 0.00, 0.00, 1.03, .03, 0.00, .74, .21,
    0.00, 0.00, .20, 3.08, 0.00, .52, 2.96, 1.02, .22, .41, .37,
    0.00, 0.00, 1.35, .17, 0.00, .21, 3*0.00,
     .45, .05, .78, 0.00, 1.56, 0.00, 0.00, .66, 2.49, .09, .58,
     .45, .01, 0.00, .01, 3*0.00, .13, .31, 0.00, .03, .39, .38,
     .13, 0.00, .03, 1.97, .01, 2*0.00,
    1.18, 0.0, 0.01, 2.15, 0.06, 0.00, 0.88, 0.00, 0.00, 0.88,
    0.04, 8*0.00, 0.07, 1.50, 0.02, 0.82, 0.06, 0.35, 2.25,
    2.59, 0.00, 2.11, 0.01,
    0.12, 0.12, 0.24, 0.05, 0.01, 0.13, 0.05, 1.32, 0.49, 0.94,
    0.11, 0.64, 0.20, 0.02, 0.27, 0.05, 0.03, 0.43, 0.00, 0.50,
    1.06, 0.66, 0.04, 0.71, 0.30, 0.00, 0.71, 0.60, 1.07, 1.03,
    0.21,
    0.09, 0.28, 0.24, 0.00, 0.51, 5*0.00, 0.05, 5*0.00, 0.08,
    0.00, 0.88, 0.06, 0.08, 0.00, 0.05, 0.00, 0.09, 0.27, 3.80,
    0.53, 1.75, 0.61,
    5.31, 0.74, 0.10, 0.00, 0.07, 0.40, 0.34, 0.42, 0.04, 0.00,
    0.00, 0.03, 0.99, 0.20, 0.00, 0.19, 0.15, 1.76, 1.92, 0.28,
    4*0.00, 0.01, 0.02, 0.11, 1.34, 1.21, 0.86, 0.15,
    0.48, 0.03, 0.00, 0.00, 0.00, 0.09, 0.01, 1.66, 0.72, 8*0.00,
    0.02, 0.13, 0.44, 0.02, 0.13, 0.07, 0.07, 0.01, 0.47, 0.00,
    0.26, 2.18, 2.10, 0.29,
    0.03, 0.07, 10*0.00, 0.20, 0.20, 0.09, 0.00, 0.01, 0.00, 0.09,
    0.38, 0.03, 7*0.00,
    6*0.00, 0.03, 0.01, 0.00, 0.11, 0.00, 0.00, 0.07, 0.57, 0.24,
    0.36, 0.16, 0.40, 2.10, 0.33, 0.00, 0.00, 0.03, 0.06, 0.47,
    0.49, 0.00, 0.00, 0.01, 0.39, 1.52, 0.03,
TMAX=-.2, .4, 1.3, 3.7, -2.0, -.7, -.9, -.3, 1.6, -1.0, 1.0, .7,
    3.0, 0.0, -7.2, -9.6, -9.0, -6.4, -6.3, -3.2, -4.4, -3.8, -.8,
    -4.8, -5.9, -5.0, -4.8, -.3, 0.0, -1.7,
    -1.1, -2.2, -2.0, .7, -3.0, -3.7, -3.0, -.7, -1.0, -.6, -1.7,
     1.3, 6.8, 3.3, -.7, 2.8, 1.1, 4.2, 5.4, 2.6, 3.7, 2.9, -2.0,
    -2.5, -.6, 4.1, 5.2, 3.0, 4.4, 5.1, 4.7,
     3.0, 5.2, 8.7, 9.6, 10.3, 4.1, -.8, 1.5, 1.4, -1.8, -4.9,
     -4.1, -2.4, 4.4, 5.1, 6.2, 6.3, 2.4, 2.9, 5.4, 5.5, 5.6, 5.7,
      3.0, 7.6, 5.3, 3.0, 2.8, 3.8, 3.5,
      8.2, 6.6, 6.7, 7.9, 9.6, 8.3, 3.2, 2.7, 8.0, 6.8, 10.3, 12.8,
     12.0, 9.7, 9.0, 10.5, 5.9, 1.5, -.5, -1.1, .9, 3.6, 8.2, 13.4,
      9.2, 11.0, 13.3, 13.3, 15.5, 14.2, 11.8,
     13.2, 11.5, 14.8, 14.6, 10.2, 11.8, 13.5, 10.6, 4.4, 6.2, 3.0,
      3.9, 13.5, 16.6, 16.7, 17.5, 17.0, 15.0, 11.7, 11.5, 14.7,
      9.7, 8.0, 8.2, 6.8, 8.3, 4.4, 1.9, 9.0, 6.1, 8.5,
     8.5,  8.3,  8.4,  4.5, 12.1,  8.6,  4.5, 10.1, 11.0,  6.4,
     9.9, 11.5, 12.9, 13.2, 12.6, 11.5, 10.1, 10.2, 10.1,  5.0,
     9.1,  4.0,  2.0,  0.2, -4.6, -4.8,  2.0,  2.4, -0.7, -2.4,
    -5.7, -6.4, -5.7, -5.1, -5.2, -5.2, -5.0, -4.8, -6.1, -4.8,
    -6.0, -5.9, -5.8, -8.0, -6.3, -9.5, -5.8, -1.5, -4.2, -3.1,
    -9.0, -5.3, -7.9, -5.7, -0.5, -2.8, -2.0, -5.7, -10.2, -10.7,
    -13.0,
    -11.3, -8.0, -5.5, -6.5, -8.4, -1.7,  1.4, -0.5,  0.5,  0.5,
     -2.0, -2.9, -5.2, -2.8, -0.3,  0.0, -2.1, -0.4, -2.5, -6.2,
     -5.7, -0.3,  2.0, -1.6, -3.9, -8.0, -4.8, -3.0,-10.8, -7.0,
     -6.1, -1.4,  0.7,  1.8, -1.2, -9.7, -6.2, -3.4, -0.3, -0.7,
    -6.5, -12.3, -10.2, -11.0, -8.0, -9.3, -3.9, -5.4, -10.1, -3.3,
      3.5,  3.7,  0.7, -1.9, -2.0, -0.5, -0.4, -0.8, -0.3, -1.4, -10.7,
     -4.6,  0.2, -0.2,  0.8, -0.4, -3.4, -3.6, -7.6, -3.5, -1.0,
      0.8, -1.2, -2.3, -0.4,  0.5, -4.2, -4.2, -4.7, -3.2, -4.5, -5.7,
     -7.7, -4.9, -5.4, -2.4, -4.0, -3.9, -6.3, -4.8, -4.8,  1.4,
     -2.6,  1.2, -3.8, -11.8, -4.5, -3.0, -2.3,  0.4, -1.0,  0.6,-1.4,
      -4.1, -6.2, -9.2, -7.0, -8.8, -3.0,  2.1, -2.1, -7.4, -0.9,
      -4.0, -4.9, -6.7, -4.2, -3.5,  1.0, -0.3,  1.6, -0.1, -2.8,
      -4.5, -3.4, -4.8, -4.0, -2.3, -2.3, -4.7, -4.5, -5.9, -4.5,
      -3.9, -6.6, -7.6, -8.2, -11.3, -8.8, -9.8, -2.2, -5.4, -9.5,
     -12.5, -13.1, -4.7, -5.6, -5.3, -10.2, -11.3, -9.5,
```

Figure 23. (Continued)

```
TMIN=-5.3, -6.2, -5.6, -3.4, -4.8, -7.4, -6.0, -6.4, -4.9, -5.3,
      -7.4, -5.2, -3.9, -8.7, -12.2, -13.2, -14.6, 2*-15.1, -10.2,
      -9.4, -9.5, -8.4, -9.1, -10.4, -10.7, -9.9, -5.4, -3.8, -4.8,
      -6.2, -7.8, -7.6, -5.2, -6.7, -6.3, -8.0, -5.5, -6.7, -3.7,
      -4.4, -7.5, 0.2, -4.4, -7.1, -3.8, -1.1, -3.7, -1.2, 0.1, -.7,
      -3.2, -6.9, -7.8, -6.7, -5.2, -1.6, -3.9, -3.6, 0.0, 2.0
      -2.4, -6.7, 1.5, 4.4, 3.3, -1.0, -5.9, -5.3, -6.3, -8.2, -7.7,
      -6.1, -6.9, -4.7, 1.2, .1, .4, -3.0, -4.6, .2, 0.0, .1, 2.2,
      -2.4, -1.4, 2.5, -.7, 0.0, -1.3, -1.3,
       2.0, -.4, .7, -2.5, 1.3, 3.0, -2.8, -2.8, .6, 1.1, 2.0, 6.1,
       6.8, 3.7, 1.4, 5.0, .8, -2.5, -3.1, -4.6, -1.7, -2.6, 1.0,
       2.3, -1.2, -2.4, 4.4, 3.3, 5.3, 6.9, 5.3,
       5.9, 6.1, 4.9, 7.3, 1.9, 2.2, 6.4, .5, .2, .2, -2.6, -2.9,
       3.2, 8.6, 10.5, 11.8, 11.2, 7.8, 4.8, 6.0, 6.8, 5.1, 4.1, 3.6,
       3.3, 3.4, -2.8, -4.4, 1.3, 2.1, 3.2,
      0.0, 1.8, 4.0, -2.6, -0.5, -2.1, -4.6, 2.8, 6.0, 0.0, 2.1, 2.8,
     4.5, 5.6, 6.4, 4.6, 3.8, 2.6, 3.5, 0.1, -1.5, -2.8, -7.0, -5.7,
    -8.6, -7.5, -8.4, -1.7, -7.5, -8.8,
    -9.8,-10.2,-11.9, -7.5, -10.4, -9.2, -8.6, -9.8, -9.8, -9.8, -8.6,
    -10.7, -12.3, -13.2, -11.7, -12.5, -14.6, -7.1, -6.4, -9.1, -12.3,
    -12.9, -12.9, -8.8, -8.2, -8.2, -8.0, -13.0, -13.6, -14.3, -17.1,
    -15.1, -15.7, -13.0, -11.0, -12.5, -9.5, -6.8, -7.8, -5.4, -4.8,
    -7.0, -7.7, -8.5, -7.4, -4.4, -3.0, -4.7, -5.4, -11.8, -12.8, -8.2,
    -7.8, -2.8, -5.3, -12.0, -13.0, -9.4, -13.5, -13.0, -13.5,
    -9.0, -10.4, -6.3, -2.0, -10.5, -11.7, -10.6, -6.5, -4.4, -7.0,
   -12.5, -17.4, -16.7, -19.0, -11.9, -12.2, -10.2, -13.3, -13.4, -10.3,
    -4.0, -1.9, -2.6, -7.9, -6.5, -5.3, -8.7, -8.8, -3.4, -14.8, -15.7,
   -10.9, -11.0, -6.6, -6.2, -7.3, -4.6, -8.2, -11.5, -13.9, -7.5, -4.9,
    -9.1, -7.2, -5.8, -5.8, -7.0, -6.3, -7.9, -9.3, -10.2, -10.0, -14.4,
   -13.9, -8.2, -6.8, -9.7, -7.7, -13.8, -10.8, -10.1, -6.9,
   -12.6, -12.6, -13.5, -14.8, -12.5, -5.6, -5.8, -6.8, -6.8, -6.8, -6.8,
    -7.1, -9.3, -13.8, -13.8, -13.0, -11.9, -6.1, -7.9, -14.4, -14.4,
    -6.6, -8.6, -12.3, -10.8, -10.1, -9.1, -4.5, -2.0, -6.1, -7.0, -8.8,
    -9.3, -9.5, -10.0, -7.1, -8.1, -9.5, -7.9, -8.8, -8.1, -9.8, -9.6,
   -11.6, -14.0, -15.7, -13.9, -18.1, -12.5, -12.9, -12.7, -15.2, -15.9,
   -13.6, -7.9, -14.3, -18.0, -14.0, -15.2,
 TCRIT=76*3.,15*2.,62*.75,61*.75,30*1.0,31*2.0,62*3.0,28*3.0,
$END
```

Figure 23. (Continued)

Table 3. Description of Parameters in NAMELIST BASE

Parameter	Symbol*	Type	Units Metric	Units English	Description
BASIN	—	R*8	—	—	Basin name
NZ	—	I*4	—	—	Number of elevation zones
IYEAR	—	I*4	—	—	Year of model run
AREA	A_z	R*8	m^2	ft^2	Area in each elevation zone
X	x	R*8	m^3s^{-1}	ft^3s^{-1}	X parameter in computing recession coefficient, K
Y	y	R*8	—	—	Y parameter in computing recession coefficient, K
PDR	—	R*4	—	—	Percentage of previous day runoff reaching the stream-gauge
PDM2	—	R*4	—	—	Percentage of runoff if more than 24 hours stream-flow lag.
DTLR	δ_{zn}	R*4	°C/100m	°F/1000ft	Average temperature lapse rate in degree–days
AN	a_{zn}	R*4	$cm \cdot {}^\circ C \cdot d^{-1}$	$in \cdot {}^\circ F \cdot d^{-1}$	Degree–day factors
CS	c_{Szn}	R*4	—	—	Snow runoff coefficient factor
CR	c_{Rzn}	R*4	—	—	Rain runoff coefficient factor
ZMEAN	$\bar{h}$	R*8	m	ft	Hypsometric mean elevation of each zone
STATN	h_{ST}	R*8	m	ft	Elevation of each base station
IPR	—	I*2	—	—	Precipitation method 0 = Non snow–covered areas 1 = Total areas

*Note: The subscript zn refers to number of snowmelt days per zone.

Table 3. (Continued)

Parameter	Symbol*	Type	Units		Description
			Metric	English	
MAXMIN	—	I*2	—	—	Flag to indicate if temperatures are input as maximum–minumum 0 = Temperatures input not as MAX–MIN 1 = Temperatures input as MAX–MIN
IEXT	—	I*2	—	—	Flag if temperatures are to be automatically extrapolated to elevation zone 0 = Extrapolate using predetermined constant 1 = Automatically extrapolated using lapse rate
IDEGDY	—	I*2	—	—	Flag if temperature is to be computed in degree-days 0 = No computation necessary. Temperature already input in degree-days 1 = Compute temperature in degree-days

*Note: The subscript zn refers to number of snowmelt days per zone.

The SRM parameters, DTLR (if required), AN, CS, CR, and IPR are parameters that change throughout the snowmelt season. These are included in the basin NAMELIST so that the user can vary these parameters without having to input the climatological NAMELIST on each run. Figure 24 shows a typical basin NAMELIST input, again on the Dischma basin in Switzerland.

The NAMELIST OPT contains program control options to properly execute the SRM program. This NAMELIST can also be read several times allowing the user the capability of making several computer runs for a particular basin at one time. A description of each program option NAMELIST parameter including type and default value are provided in Table 4. Numerous program options are provided to the user such as plotting and printing options. The user may wish to operate in either metric or English units, so an option is provided for the appropriate conversion of units (UFLAG). It should be noted that the user must be consistent in inputting all data in either metric

```
1
 &BASE
  BASIN='DISCHMA ','BASIN    ',
  NZ=3,
  IYEAR=1974,
  AREA=8.9D6, 2.45D7, 9.9D6, 5*0.DO,
  X=0.921DO,
  Y=-0.0426DO,
  QNS=0.56DO,
  PDR=367*.5,
  PDM2=367*0.,
  DTLR=2928*0.65,
  AN=15*.4,15*.45,31*.45,30*.50,46*.55,46*.60,123*.25,59*.3,0.,
      15*.4,15*.45,31*.45,30*.50,46*.55,46*.60,123*.25,59*.3,0.,
      15*.4,15*.45,31*.45,30*.50,46*.55,46*.60,123*.25,59*.3,0.,
  CS=45*.95,16*.9,61*.85,31*.80,30*.9,182*.95,0.,
      45*.95,16*.9,61*.85,31*.80,30*0.9,182*.95,0.,
      45*.95,16*.9,61*.85,31*.80,30*0.9,182*.95,0.,
  CR=91*1.0,123*0.7,151*0.6,
  ZMEAN=1938.DO,2370.DO,2750.DO,5*0.DO,
  STATN=2677.DO,
  MAXMIN=1,
  IEXT=1,
  IDEGDY=1,
  IPR=76*0,199*1,91*0,
         76*0,199*1,91*0,
         76*0,199*1,91*0,
 &END
```

Figure 24. Sample NAMELIST BASE input for the Dischma basin, 1974.

Table 4. Description of Parameters in NAMELIST OPT

Parameter	Default	Type	Description
IRUN	1	I*4	Model run number
MODE	0	I*4	Simulation/Forecast mode flag 0 = Simulation 1 = Forecast
IPLT	0	I*2	Plotting option flag 0 = No plot 1 = Plot
IPRINT	0	I*2	Printing option flag 0 = No print 1 = Print
UFLAG	0	I*2	Units option flag 0 = Metric units 1 = English units
ACTFLG	1	I*2	Actual data flag 0 = No actual data available 1 = Actual data available
IZONE	3*1	I*2	Temperature, precipitation and runoff coefficient zone flag IZONE (1) = Temperature lapse rate IZONE (2) = Precipitation IZONE (3) = Runoff coefficients 0 = No zone input 1 = Input by zone
IDTFLG	0	I*2	Adjustment for temperature lapse rate data flag 0 = No temperature lapse rate data available 1 = Temperature lapse rate data available
MTHD	0	I*2	Degree-day temperature computation flag 0 = Mean method 1 = Effective minimum
ITPROC	0	I*2	Temperature processing flag to extrapolate temperatures and compute degree-days 0 = No temperature lapse rate processing 1 = Temperature lapse rate processing
IPRRUN	1	I*2	Runoff print option flag 0 = No print 1 = Print runoff values by zones
ISTMTH	4	I*4	Starting month of snowmelt run
IENMTH	9	I*4	Ending month of snowmelt run

or English units. No mixing of units is allowed and the unit option chosen must correspond to the units input into the program. In the event that no actual (measured) streamflow data is available, the user must input an initial actual streamflow value for the first day in place of actual data (ACTUAL (1)). An actual data flag must be set by the user indicating to the program that no actual data is available (ACTFLG). The model run identifying number, IRUN, is the only program option NAMELIST parameter required. All other NAMELIST parameters not specified will default to BLOCK DATA values which have been chosen to provide the basic options to properly execute the SRM program. Figure 25 shows typical program option NAMELIST input for the Dischma basin.

```
&OPT
 IRUN=1,
 MODE=0,
 IPLT=0,
 IPRINT=1,
 UFLAG=0,
 ACTFLG=1,
 IZONE=0,0,0,
 IDTFLG=1,
 MTHD=0,
 ITPROC=1,
 IPRRUN=1,
 ISTMTH=4,
 IENMTH=7,
&END
```

Figure 25. Sample NAMELIST OPT input for the Dischma basin, 1974.

Temperature Input Processing

The format in which temperature data are received can vary widely for each basin. Temperatures can be input as hourly readings, as average daily temperatures in degrees or degree-days, or as maximum and minimum values for one or two observing stations. Because the SRM computations for runoff will only accept temperature input in degree-days for each elevation zone, a certain amount of preprocessing is required if temperatures are not in that format.

To obtain temperatures in the proper format, a temperature preprocessing routine LAPSE is called to convert temperatures in degrees to degree-days (if they are not in that form) and to extrapolate degree-day temperatures to the elevation zones. When daily maximum and minimum temperatures are input, the temperature preprocessing routine LAPSE can be used to convert temperatures from degrees to degree-days. This is accomplished automatically in the program when the user sets the flags MAXMIN and IDEGDY to 1. The degree-day temperatures can be computed by setting the flag MTHD for effective minimum or mean method. The routine LAPSE can also accomodate temperatures that are input as an average daily value in degrees or as daily temperatures already converted to degree-days.

Additionally, the routine LAPSE will automatically extrapolate degree-day temperatures to the elevation zones according to Equation (4) provided the flag IEXT is set to 1. For the program to automatically extrapolate temperatures to the elevation zones the user must supply the mean elevation in each zone ZMEAN ($\bar{h}$), the elevation of the temperature base station, STATN (h_{ST}), and the average lapse rate DTLR (δ). In cases where the average lapse rate is predetermined for each elevation zone (rather than calculated from actual temperature data), no extrapolation is required beyond the addition of the lapse rate value to the degree-day temperature.

In special cases where temperatures are input hourly or as maximum-minimum from two stations, the modular routine PRETMP must be used to obtain the appropriate degree-day values for SRM. This routine is not part of the normal SRM processing and is included in Appendix C. PRETMP requires more storage capabilities and can be used as is or as a guideline for more detailed temperature preprocessing.

Precipitation Input Processing

The SRM program handles precipitation falling during snowmelt in several ways. First, based on a critical threshold temperature, a decision is made as to whether the precipitation is snow or rain. If it is snow and it falls on the existing snowpack, it is assumed to be melted along with the original snow later in the season as soon as the degree-day totals are sufficient. If it is snow and it falls on the snow-free area of the basin, the new snow is treated as transient snow and is melted right after the storm as soon as temperatures rise sufficiently. This input is treated merely as delayed rainfall. The situation with respect to rainfall is more complex because of the nature of the snowpack during the snowmelt season. In all cases rain falling on non snow-covered areas is automatically added to snowmelt by the model. In the early days of the snowmelt season, however, rain falling on the snow-covered region is assumed to fall on dry snow and it is held by the snowpack as part of the ripening process. Later in the snowmelt season over the snow-covered area, rain is assumed to fall on a ripe snowpack and this water is transmitted through the snow and added by the model to snowmelt.

Based on the progression of the snowmelt season, the program user must input daily the precipitation calculation method (IPR) desired (0 = rain added to snowmelt from snow-free areas only, i.e., a dry snowpack or 1 = rain added to snowmelt from all basin areas, i.e., a ripe snowpack).

Streamflow Input

Provision is made in the SRM program to take into account streamflow lag which can vary as the snowmelt season progresses. The streamflow lag is usually specified in hours, however, the effect on streamflow simulation in the model is expressed as the percentage of streamflow recorded on day n that is actually a result of snowmelt from the previous day (n–1). In the case of the South Fork basin in Colorado, it was determined that early in the snowmelt season approximately 70% of the streamflow recorded on day n is the result of the prior day's snowmelt amount, and 30% of the streamflow on day n is from snowmelt occurring on day n. The input to the program is therefore set at PDR = 0.70. Provision is also made in the model for when streamflow lag exceeds 18 hours. In this case there is no runoff contribution on day n from snowmelt occurring on day n. Streamflow occurring on day n is a result of snowmelt occurring on days n–1 and n–2. To reflect this situation, the input parameter PDM2 is set equal to the percentage of day n streamflow contribution resulting from day n–2 snowmelt.

The SRM program can be run in a streamflow simulation or forecast mode by specifying the MODE parameter in NAMELIST OPT. In the forecast mode, the model calculated daily streamflow value can be updated every seventh day with measured streamflow for an entire snowmelt season run. In the default condition, SRM runs in the streamflow simulation mode.

Job Control Language

The snowmelt–runoff model program can be operated in a batch mode via card deck as shown in Figure 26. The only IBM 3081 Job Control Language (JCL) required to execute the program is shown below.

```
//JOB CARD                    (User supplied Job and accounting information)

//EXEC FORTRAN                (Compiler type and options)

//SOURCE SYSIN DD*

         •
         •                    (Include FORTRAN source deck)
         •

//EXEC LOADER                 (Loader size and options)

//GO.FT06F001 SYSOUT =A                  (Output device)

//DATA5 DD*
         •
         •                    (Include NAMELIST CLIM)
         •
         •                    (Include NAMELIST BASE)
         •
         •                    (Include NAMELIST OPT)

/*
```

Program Output Capabilities

The output of the SRM program consists of various numerical results and printer plots of the actual versus computed hydrographs. Depending on the purpose of the computer run, all or part of the output products may be produced.

The numerical output results consist of the measured versus calculated daily discharge rate for the snowmelt period (or entire year), the actual and computed total volume of streamflow for the snowmelt period (or entire year), the percent seasonal difference between the actual streamflow and the calculated streamflow (D_V), the mean actual and calculated streamflows, the Nash-Sutcliffe "goodness of fit" measure, the daily calculated snowmelt depth by elevation zone, and the computed daily precipitation values in each of the basin elevation zones. Table 5 provides a brief description of the output variables.

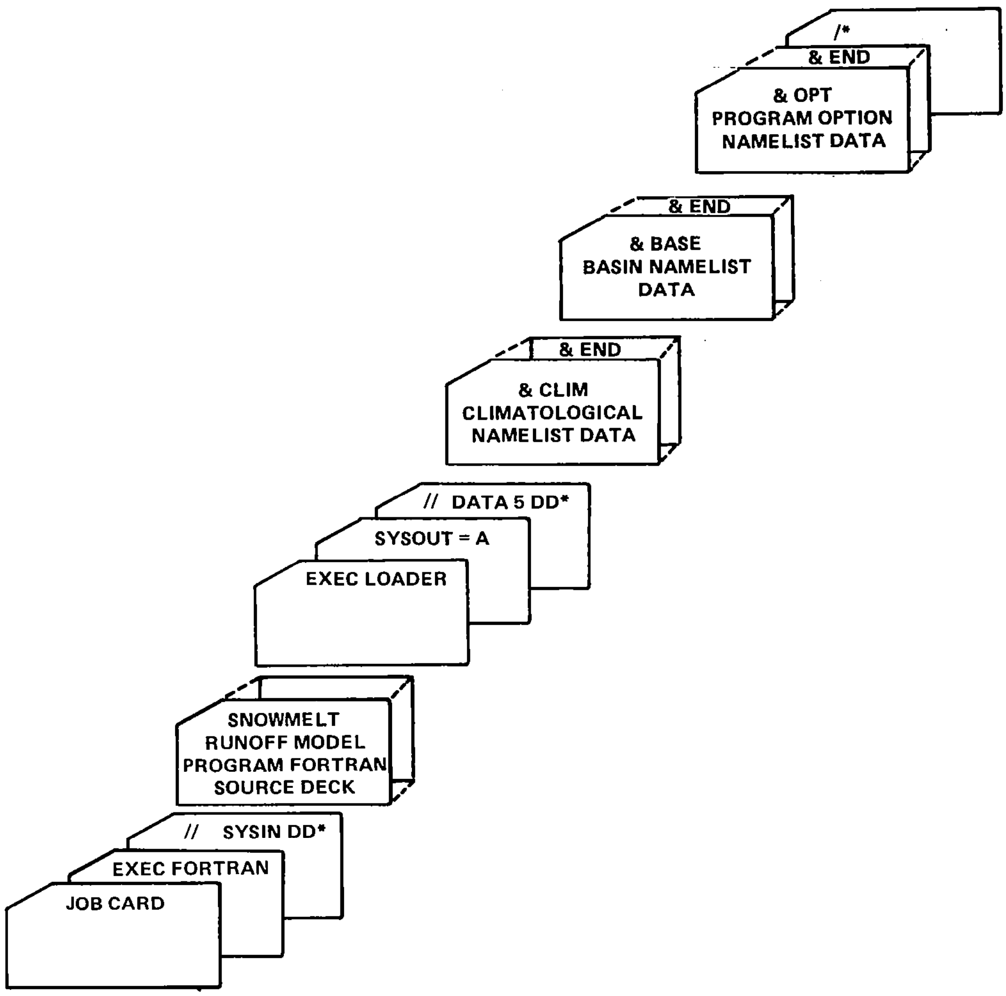


Figure 26. Sample card deck for input of snowmelt-runoff model program.

Table 5.
Description of Output Variables

Variable	Symbol	Type	Description
P	P_{zn}	R*4	Precipitation contributing to runoff in each zone assigned every day
RUNOF	–	R*4	Total depth (precipitation + snowmelt) contributing to runoff in each zone
QNP1X	Q_{n+1}	R*4	Computed stream runoff for next day
XNSR2	R^2	R*4	Nash–Sutcliffe 'goodness of fit' measure
VOL	–	R*4	Computed volume for predicted runoff
AVOL	–	R*4	Computed volume for actual runoff
PCT	D_v	R*4	Percent seasonal difference between actual and predicted runoff
AMEAN	–	R*4	Mean actual stream runoff
QMEAN	–	R*4	Mean computed stream runoff

A printer plot can be generated using the FORTRAN PRPLOT plotting package supplied with the snowmelt–runoff model. A listing for PRPLOT is included as part of Appendix B. The calculated and actual streamflows over the snowmelt–runoff season are plotted on the same graph as discharge rate vs. time. If no actual data is available then only the calculated runoff is plotted if desired. Figure 27 gives an example of some numerical results for the Dischma basin for 1974.

```
    RUN #     1  BASIN=DISCHMA BASIN      YEAR= 1974

MODE (0=SIMULATED,1==FORCAST)=  0


PROGRAM OPTIONS (0=OFF,1=ON)

PLOT OPTION= 0  PRINT OPTION= 1  UNITS(0=METRIC,1=ENGLISH)= 0

ACTUAL DATA FLAG= 1  ZONE INPUT DATA(TEMP.,PRECIP.,RUNOFF COEF.)= 0 0 0

LAPSE RATE DATA FLAG= 1  DEGREE-DAY METHOD(0=MEAN,1=EFFECTIVE MINIMUM)= 0

TEMPERATURE PROCESSING FLAG= 1  RUNOFF BY ZONE OUTPUT OPTION= 1

FLAG TO EXTRAPOLATE TEMPERATURES(0=EXTRAPOLATE USING GIVEN LAPSE RATES, 1=AUTOMATICALLY EXTRAPOLATE)= 1

FLAG TO COMPUTE DEGREE-DAYS= 1

FLAG TO INDICATE INPUT TEMPS ARE MAX-MIN= 1

START MONTH= 4  END MONTH= 7


NUMBER OF SNOWMELT DAYS=  122      NUMBER OF ELEVATION ZONES=    3


    RECESSION COEFFIECIENT FACTORS

X FACTOR= 0.921000 Y FACTOR=-0.042600

INITIAL RUNOFF VALUE=     0.560    LAG=  6 HOURS

    AREA IN EACH ELEVATION ZONE

ZONE      AREA (SQ. METERS   )
   1         0.8900D 07
   2         0.2450D 08
   3         0.9900D 07

    HYPSOMETRIC MEAN ELEVATION IN EACH ZONE (METERS   )

   1         0.1938D 04
   2         0.2370D 04
   3         0.2750D 04

    BASE STATION ELEVATION (METERS   )

    0.2677D 04
```

Figure 27. Snowmelt–runoff model results for the Dischma basin, 1974.

DAILY MAXIMUM AND MINIMUM TEMPERATURES

RANGO-MARTINEC MODEL FOR DISCHMA BASIN YEAR= 1974

DAY	APR		MAY		JUN		JUL	
	MAX TEMP	MIN TEMP	MAX TEMP	MIN TEMP	MAX TEMP	MIN TEMP	MAX TEMP	MIN TEMP
1	-0.20	-5.30	-1.10	-6.20	3.00	-2.40	8.20	2.00
2	0.40	-6.20	-2.20	-7.80	5.20	-6.70	6.60	-0.40
3	1.30	-5.60	-2.00	-7.60	8.70	1.50	6.70	0.70
4	3.70	-3.40	0.70	-5.20	9.60	4.40	7.90	-2.50
5	-2.00	-4.80	-3.00	-6.70	10.30	3.30	9.60	1.30
6	-0.70	-7.40	-3.70	-6.30	4.10	-1.00	8.30	3.00
7	-0.90	-6.00	-3.00	-8.00	-0.80	-5.90	3.20	-2.80
8	-0.30	-6.40	-0.70	-5.50	1.50	-5.30	2.70	-2.80
9	1.60	-4.90	-1.00	-6.70	1.40	-6.30	8.00	0.60
10	-1.00	-5.30	-0.60	-3.70	-1.80	-8.20	6.80	1.10
11	1.00	-7.40	-1.70	-4.40	-4.90	-7.70	10.30	2.00
12	0.70	-5.20	1.30	-7.50	-4.10	-6.10	12.80	6.10
13	3.00	-3.90	6.80	0.20	-2.40	-6.90	12.00	6.80
14	0.0	-8.70	3.30	-4.40	4.40	-4.70	9.70	3.70
15	-7.20	-12.20	-0.70	-7.10	5.10	1.20	9.00	1.40
16	-9.60	-13.20	2.80	-3.80	6.20	0.10	10.50	5.00
17	-9.00	-14.60	1.10	-1.10	6.30	0.40	5.90	0.80
18	-6.40	-15.10	4.20	-3.70	2.40	-3.00	1.50	-2.50
19	-6.30	-15.10	5.40	-1.20	2.90	-4.60	-0.50	-3.10
20	-3.20	-10.20	2.60	0.10	5.40	0.20	-1.10	-4.60
21	-4.40	-9.40	3.70	-0.70	5.50	0.0	0.90	-1.70
22	-3.80	-9.50	2.90	-3.20	5.60	0.10	3.60	-2.60
23	-0.80	-8.40	-2.00	-6.90	5.70	2.20	8.20	1.00
24	-4.80	-9.10	-2.50	-7.80	3.00	-2.40	13.40	2.30
25	-5.90	-10.40	-0.60	-6.70	7.60	-1.40	9.20	-1.20
26	-5.00	-10.70	4.10	-5.20	5.30	2.50	11.00	-2.40
27	-4.80	-9.90	5.20	-1.60	3.00	-0.70	13.30	4.40
28	-0.30	-5.40	3.00	-3.90	2.80	0.0	13.30	3.30
29	0.0	-3.80	4.40	-3.60	3.80	-1.30	15.50	5.30
30	-1.70	-4.80	5.10	0.0	3.50	-1.30	14.20	6.90
31	******	******	4.70	2.00	******	******	11.80	5.30

DEGREE-DAY FACTORS(AN),RUNOFF COEFFICIENTS FOR SNOW(CS), FOR RAIN(CR), PRECIP METHOD(PR)

RANGO-MARTINEC MODEL FOR DISCHMA BASIN YEAR= 1974

DATA FOR ZONE A

DAY	APR				MAY				JUN				JUL			
	AN	CS	CR	PR	AN	CS	CR	PR	AN	CS	CR	PR	AN	CS	CR	PR
1	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
2	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
3	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
4	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
5	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
6	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
7	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
8	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
9	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
10	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
11	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
12	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
13	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
14	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
15	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
16	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
17	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
18	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
19	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
20	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
21	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
22	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
23	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
24	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
25	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
26	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
27	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
28	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
29	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
30	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
31	****	****	****	*	0.45	0.90	1.00	0	****	****	****	*	0.55	0.85	0.70	1

Figure 27. (Continued)

DEGREE-DAY FACTORS(AN),RUNOFF COEFFICIENTS FOR SNOW(CS), FOR RAIN(CR), PRECIP METHOD(PR)

RANGO-MARTINEC MODEL FOR DISCHMA BASIN YEAR= 1974

DATA FOR ZONE B

DAY	APR				MAY				JUN				JUL			
	AN	CS	CR	PR	AN	CS	CR	PR	AN	CS	CR	PR	AN	CS	CR	PR
1	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
2	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
3	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
4	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
5	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
6	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
7	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
8	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
9	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
10	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
11	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
12	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
13	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
14	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
15	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
16	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
17	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
18	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
19	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
20	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
21	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
22	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
23	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
24	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
25	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
26	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
27	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
28	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
29	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
30	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
31	****	****	****	*	0.45	0.90	1.00	0	****	****	****	*	0.55	0.85	0.70	1

DEGREE-DAY FACTORS(AN),RUNOFF COEFFICIENTS FOR SNOW(CS), FOR RAIN(CR), PRECIP METHOD(PR)

RANGO-MARTINEC MODEL FOR DISCHMA BASIN YEAR= 1974

DATA FOR ZONE C

DAY	APR				MAY				JUN				JUL			
	AN	CS	CR	PR	AN	CS	CR	PR	AN	CS	CR	PR	AN	CS	CR	PR
1	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
2	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
3	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
4	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
5	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
6	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
7	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
8	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
9	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
10	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
11	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
12	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
13	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
14	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
15	0.40	0.95	1.00	0	0.45	0.95	1.00	0	0.50	0.85	1.00	0	0.55	0.85	0.70	1
16	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
17	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
18	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
19	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
20	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
21	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
22	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
23	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
24	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
25	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
26	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
27	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
28	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
29	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
30	0.45	0.95	1.00	0	0.45	0.90	1.00	0	0.50	0.85	1.00	1	0.55	0.85	0.70	1
31	****	****	****	*	0.45	0.90	1.00	0	****	****	****	*	0.55	0.85	0.70	1

Figure 27. (Continued)

LAPSE RATE(DTLR), CRITICAL TEMPERATURE(TCRT)

RANGO-MARTINEC MODEL FOR DISCHMA BASIN YEAR= 1974

DATA FOR ZONE A

DAY	APR DTLR	APR TCRT	MAY DTLR	MAY TCRT	JUN DTLR	JUN TCRT	JUL DTLR	JUL TCRT
1	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
2	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
3	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
4	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
5	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
6	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
7	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
8	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
9	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
10	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
11	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
12	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
13	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
14	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
15	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
16	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
17	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
18	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
19	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
20	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
21	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
22	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
23	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
24	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
25	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
26	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
27	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
28	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
29	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
30	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
31	******	****	0.65	3.00	******	****	0.65	0.75

LAPSE RATE(DTLR), CRITICAL TEMPERATURE(TCRT)

RANGO-MARTINEC MODEL FOR DISCHMA BASIN YEAR= 1974

DATA FOR ZONE B

DAY	APR DTLR	APR TCRT	MAY DTLR	MAY TCRT	JUN DTLR	JUN TCRT	JUL DTLR	JUL TCRT
1	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
2	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
3	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
4	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
5	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
6	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
7	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
8	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
9	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
10	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
11	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
12	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
13	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
14	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
15	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
16	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
17	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
18	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
19	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
20	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
21	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
22	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
23	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
24	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
25	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
26	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
27	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
28	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
29	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
30	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
31	******	****	0.65	3.00	******	****	0.65	0.75

Figure 27. (Continued)

LAPSE RATE(DTLR), CRITICAL TEMPERATURE(TCRT)

RANGO-MARTINEC MODEL FOR DISCHMA BASIN YEAR= 1974

DATA FOR ZONE C

DAY	APR		MAY		JUN		JUL	
	DTLR	TCRT	DTLR	TCRT	DTLR	TCRT	DTLR	TCRT
1	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
2	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
3	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
4	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
5	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
6	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
7	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
8	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
9	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
10	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
11	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
12	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
13	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
14	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
15	0.65	3.00	0.65	3.00	0.65	3.00	0.65	0.75
16	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
17	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
18	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
19	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
20	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
21	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
22	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
23	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
24	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
25	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
26	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
27	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
28	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
29	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
30	0.65	3.00	0.65	3.00	0.65	2.00	0.65	0.75
31	******	****	0.65	3.00	******	****	0.65	0.75

DAILY TEMP IN DEGREE-DAYS(DD),INPUT PRECIP(PREC), SNOW COVERED AREA IN %(SCA::)

RANGO-MARTINEC MODEL FOR DISCHMA BASIN YEAR= 1974

DATA FOR ZONE A

DAY	APR			MAY			JUN			JUL		
	DD	PREC	SCA	DD	PREC	SCA	DD	PREC	SCA	DD	PREC	SCA
1	2.05	0.19	0.880	1.15	0.21	0.800	5.10	1.49	0.230	9.90	0.0	0.030
2	1.90	0.06	0.880	0.0	0.22	0.795	4.05	0.0	0.215	7.90	0.57	0.025
3	2.65	0.0	0.875	0.00	0.03	0.795	9.90	0.0	0.200	8.50	0.0	0.025
4	4.95	0.0	0.875	2.55	0.0	0.790	11.80	0.0	0.185	7.50	0.89	0.020
5	1.40	0.04	0.875	0.0	0.45	0.785	11.60	0.0	0.179	10.25	0.0	0.018
6	0.75	0.34	0.875	0.0	0.84	0.780	6.35	0.37	0.170	10.45	0.0	0.015
7	1.35	0.0	0.870	0.0	0.09	0.775	1.45	0.02	0.160	5.00	1.03	0.010
8	1.45	0.01	0.870	1.70	0.01	0.770	2.90	0.06	0.150	4.75	0.03	0.005
9	3.15	0.0	0.865	0.95	0.0	0.765	2.35	0.07	0.140	9.10	0.0	0.0
10	1.65	0.0	0.865	2.65	0.0	0.760	0.0	0.41	0.135	8.75	0.74	0.0
11	1.60	0.0	0.865	1.75	0.27	0.760	0.0	0.85	0.125	10.95	0.21	0.0
12	2.55	0.0	0.860	1.70	0.98	0.755	0.0	1.06	0.115	14.25	0.0	0.0
13	4.35	0.0	0.860	8.30	0.0	0.745	0.15	1.72	0.110	14.20	0.0	0.0
14	0.45	0.10	0.855	4.25	0.02	0.735	4.65	0.03	0.105	11.50	0.20	0.0
15	0.0	0.03	0.850	0.90	0.27	0.725	7.95	0.0	0.100	10.00	3.08	0.0
16	0.0	0.53	0.850	4.30	0.0	0.717	7.95	0.66	0.095	12.55	0.0	0.0
17	0.0	0.13	0.845	4.80	0.0	0.700	8.15	0.0	0.090	8.15	0.52	0.0
18	0.0	0.07	0.840	5.05	0.0	0.680	4.50	0.70	0.085	4.30	2.96	0.0
19	0.0	0.02	0.835	6.90	0.0	0.660	3.95	1.20	0.080	3.00	1.02	0.0
20	0.0	0.0	0.835	6.15	0.0	0.640	7.60	0.0	0.075	1.95	0.22	0.0
21	0.0	0.0	0.830	6.30	0.26	0.600	7.55	0.0	0.070	4.40	0.41	0.0
22	0.0	0.03	0.830	4.65	0.0	0.560	7.65	1.41	0.065	5.30	0.37	0.0
23	0.20	0.0	0.825	0.35	3.23	0.520	8.75	0.65	0.060	9.40	0.0	0.0
24	0.0	0.26	0.825	0.0	0.48	0.480	5.10	1.59	0.055	12.65	0.0	0.0
25	0.0	0.59	0.820	1.15	0.38	0.440	7.90	0.09	0.050	8.80	1.35	0.0
26	0.0	0.31	0.820	4.25	0.03	0.400	8.70	0.0	0.045	9.10	0.17	0.0
27	0.0	0.02	0.815	6.60	0.0	0.370	5.95	2.71	0.040	13.65	0.0	0.0
28	1.95	0.0	0.810	4.35	0.52	0.340	6.20	0.83	0.035	13.10	0.21	0.0
29	2.90	0.02	0.805	5.20	0.97	0.310	6.05	1.33	0.035	15.20	0.0	0.0
30	1.55	0.13	0.800	7.35	0.0	0.280	5.90	1.82	0.030	15.35	0.0	0.0
31	******	*****	*****	8.15	0.02	0.250	******	*****	*****	13.35	0.0	0.0

Figure 27. (Continued)

DAILY TEMP IN DEGREE-DAYS(DD),INPUT PRECIP(PREC), SNOW COVERED AREA IN %(SCA::)

RANGO-MARTINEC MODEL FOR DISCHMA BASIN YEAR= 1974

DATA FOR ZONE B

DAY	APR			MAY			JUN			JUL		
	DD	PREC	SCA	DD	PREC	SCA	DD	PREC	SCA	DD	PREC	SCA
1	0.0	0.19	0.930	0.0	0.21	0.900	2.30	1.49	0.800	7.10	0.0	0.510
2	0.0	0.06	0.930	0.0	0.22	0.900	1.25	0.0	0.795	5.10	0.57	0.500
3	0.0	0.0	0.930	0.0	0.03	0.900	7.10	0.0	0.790	5.70	0.0	0.490
4	2.15	0.0	0.930	0.0	0.0	0.900	9.00	0.0	0.785	4.70	0.89	0.480
5	0.0	0.04	0.930	0.0	0.45	0.900	8.80	0.0	0.776	7.45	0.0	0.464
6	0.0	0.34	0.925	0.0	0.84	0.895	3.55	0.37	0.770	7.65	0.0	0.450
7	0.0	0.0	0.925	0.0	0.09	0.895	0.0	0.02	0.770	2.20	1.03	0.440
8	0.0	0.01	0.925	0.0	0.01	0.895	0.10	0.06	0.750	1.95	0.03	0.430
9	0.35	0.0	0.925	0.0	0.0	0.890	0.0	0.07	0.740	6.30	0.0	0.415
10	0.0	0.0	0.925	0.0	0.0	0.890	0.0	0.41	0.735	5.95	0.74	0.400
11	0.0	0.0	0.920	0.0	0.27	0.885	0.0	0.85	0.725	8.15	0.21	0.385
12	0.0	0.0	0.920	0.0	0.98	0.885	0.0	1.06	0.715	11.45	0.0	0.370
13	1.55	0.0	0.920	5.50	0.0	0.880	0.0	1.72	0.705	11.40	0.0	0.360
14	0.0	0.10	0.920	1.45	0.02	0.880	1.85	0.03	0.695	8.70	0.20	0.350
15	0.0	0.03	0.920	0.0	0.27	0.880	5.15	0.0	0.685	7.20	3.08	0.340
16	0.0	0.53	0.915	1.50	0.0	0.877	5.15	0.66	0.670	9.75	0.0	0.330
17	0.0	0.13	0.915	2.00	0.0	0.875	5.35	0.0	0.660	5.35	0.52	0.320
18	0.0	0.07	0.915	2.25	0.0	0.870	1.70	0.70	0.650	1.50	2.96	0.305
19	0.0	0.02	0.915	4.10	0.0	0.865	1.15	1.20	0.640	0.20	1.02	0.290
20	0.0	0.0	0.915	3.35	0.0	0.860	4.80	0.0	0.630	0.0	0.22	0.280
21	0.0	0.0	0.910	3.50	0.26	0.855	4.75	0.0	0.620	1.60	0.41	0.270
22	0.0	0.03	0.910	1.85	0.0	0.850	4.85	1.41	0.610	2.50	0.37	0.260
23	0.0	0.0	0.910	0.0	3.23	0.845	5.95	0.65	0.600	6.60	0.0	0.245
24	0.0	0.26	0.910	0.0	0.48	0.840	2.30	1.59	0.590	9.85	0.0	0.230
25	0.0	0.59	0.910	0.0	0.38	0.835	5.10	0.09	0.580	6.00	1.35	0.220
26	0.0	0.31	0.905	1.45	0.03	0.830	5.90	0.0	0.565	6.30	0.17	0.210
27	0.0	0.02	0.905	3.80	0.0	0.825	3.15	2.71	0.550	10.85	0.0	0.195
28	0.0	0.0	0.905	1.55	0.52	0.820	3.40	0.83	0.540	10.30	0.21	0.180
29	0.10	0.02	0.900	2.40	0.97	0.815	3.25	1.33	0.530	12.40	0.0	0.170
30	0.0	0.13	0.900	4.55	0.0	0.810	3.10	1.82	0.520	12.55	0.0	0.160
31	******	*****	*****	5.35	0.02	0.800	******	*****	*****	10.55	0.0	0.155

DAILY TEMP IN DEGREE-DAYS(DD),INPUT PRECIP(PREC), SNOW COVERED AREA IN %(SCA::)

RANGO-MARTINEC MODEL FOR DISCHMA BASIN YEAR= 1974

DATA FOR ZONE C

DAY	APR			MAY			JUN			JUL		
	DD	PREC	SCA	DD	PREC	SCA	DD	PREC	SCA	DD	PREC	SCA
1	0.0	0.19	0.850	0.0	0.21	0.805	0.0	1.49	0.790	4.63	0.0	0.790
2	0.0	0.06	0.845	0.0	0.22	0.805	0.0	0.0	0.790	2.63	0.57	0.790
3	0.0	0.0	0.845	0.0	0.03	0.805	4.63	0.0	0.790	3.23	0.0	0.790
4	0.0	0.0	0.840	0.0	0.0	0.805	6.53	0.0	0.790	2.23	0.89	0.795
5	0.0	0.04	0.840	0.0	0.45	0.805	6.33	0.0	0.786	4.98	0.0	0.797
6	0.0	0.34	0.835	0.0	0.84	0.805	1.08	0.37	0.785	5.18	0.0	0.795
7	0.0	0.0	0.835	0.0	0.09	0.805	0.0	0.02	0.785	0.0	1.03	0.790
8	0.0	0.01	0.830	0.0	0.01	0.805	0.0	0.06	0.785	0.0	0.03	0.785
9	0.0	0.0	0.830	0.0	0.0	0.805	0.0	0.07	0.780	3.83	0.0	0.780
10	0.0	0.0	0.830	0.0	0.0	0.805	0.0	0.41	0.780	3.48	0.74	0.775
11	0.0	0.0	0.825	0.0	0.27	0.805	0.0	0.85	0.780	5.68	0.21	0.770
12	0.0	0.0	0.825	0.0	0.98	0.805	0.0	1.06	0.785	8.98	0.0	0.760
13	0.0	0.0	0.820	3.03	0.0	0.805	0.0	1.72	0.785	8.93	0.0	0.750
14	0.0	0.10	0.820	0.0	0.02	0.805	0.0	0.03	0.785	6.23	0.20	0.740
15	0.0	0.03	0.820	0.0	0.27	0.805	2.68	0.0	0.785	4.73	3.08	0.730
16	0.0	0.53	0.815	0.0	0.0	0.804	2.68	0.66	0.785	7.28	0.0	0.720
17	0.0	0.13	0.815	0.0	0.0	0.800	2.88	0.0	0.785	2.88	0.52	0.710
18	0.0	0.07	0.810	0.0	0.0	0.800	0.0	0.70	0.785	0.0	2.96	0.700
19	0.0	0.02	0.810	1.63	0.0	0.800	0.0	1.20	0.785	0.0	1.02	0.690
20	0.0	0.0	0.810	0.88	0.0	0.800	2.33	0.0	0.785	0.0	0.22	0.675
21	0.0	0.0	0.805	1.03	0.26	0.800	2.28	0.0	0.785	0.0	0.41	0.660
22	0.0	0.03	0.805	0.0	0.0	0.800	2.38	1.41	0.785	0.03	0.37	0.645
23	0.0	0.0	0.805	0.0	3.23	0.800	3.48	0.65	0.785	4.13	0.0	0.630
24	0.0	0.26	0.805	0.0	0.48	0.800	0.0	1.59	0.785	7.38	0.0	0.615
25	0.0	0.59	0.805	0.0	0.38	0.800	2.63	0.09	0.785	3.53	1.35	0.600
26	0.0	0.31	0.805	0.0	0.03	0.795	3.43	0.0	0.785	3.83	0.17	0.585
27	0.0	0.02	0.805	1.33	0.0	0.795	0.68	2.71	0.785	8.38	0.0	0.570
28	0.0	0.0	0.805	0.0	0.52	0.795	0.93	0.83	0.785	7.83	0.21	0.560
29	0.0	0.02	0.805	0.0	0.97	0.795	0.78	1.33	0.785	9.93	0.0	0.550
30	0.0	0.13	0.805	2.08	0.0	0.795	0.63	1.82	0.790	10.08	0.0	0.540
31	******	*****	*****	2.88	0.02	0.790	******	*****	*****	8.08	0.0	0.530

Figure 27. (Continued)

DAILY SNOW DEPTH BY ZONE IN CM.M**2(DPTH), DAILY COMPUTED PRECIP CONTRIBUTING TO RUNOFF(CPRE)

RANGO-MARTINEC MODEL FOR DISCHMA BASIN YEAR= 1974

DATA FOR ZONE A

DAY	APR		MAY		JUN		JUL	
	DPTH	CPRE	DPTH	CPRE	DPTH	CPRE	DPTH	CPRE
1	0.723	0.0	0.415	0.0	1.734	1.147	0.163	0.0
2	0.670	0.0	0.0	0.0	0.436	0.0	0.679	0.570
3	0.960	0.031	0.001	0.0	0.990	0.0	0.117	0.0
4	1.734	0.0	1.149	0.241	1.092	0.0	0.973	0.890
5	0.491	0.0	0.0	0.0	1.039	0.0	0.103	0.0
6	0.264	0.0	0.0	0.0	0.847	0.307	0.086	0.0
7	0.520	0.049	0.0	0.0	0.116	0.0	1.058	1.030
8	0.506	0.0	0.590	0.0	0.218	0.0	0.043	0.030
9	1.092	0.001	0.429	0.101	0.165	0.0	0.0	0.0
10	0.572	0.0	1.194	0.287	0.0	0.0	0.740	0.740
11	0.555	0.0	0.600	0.0	0.0	0.0	0.210	0.210
12	0.878	0.0	0.579	0.0	0.0	0.0	0.0	0.0
13	1.498	0.0	3.191	0.407	0.008	0.0	0.0	0.0
14	0.155	0.0	1.412	0.005	2.354	2.109	0.200	0.200
15	0.0	0.0	0.295	0.0	2.075	1.677	3.080	3.080
16	0.0	0.0	1.465	0.076	1.038	0.660	0.0	0.0
17	0.0	0.0	1.513	0.0	0.367	0.0	0.520	0.520
18	0.0	0.0	1.546	0.0	0.891	0.700	2.960	2.960
19	0.0	0.0	2.050	0.0	1.358	1.200	1.020	1.020
20	0.0	0.0	1.772	0.0	0.285	0.0	0.220	0.220
21	0.0	0.0	1.806	0.104	0.264	0.0	0.410	0.410
22	0.0	0.0	1.173	0.0	1.659	1.410	0.370	0.370
23	0.092	0.016	0.083	0.0	0.913	0.650	0.0	0.0
24	0.0	0.0	0.0	0.0	1.730	1.590	0.0	0.0
25	0.0	0.0	0.228	0.0	0.288	0.090	1.350	1.350
26	0.0	0.0	1.932	1.166	0.196	0.0	0.170	0.170
27	0.0	0.0	2.470	1.371	2.829	2.710	0.0	0.0
28	0.879	0.167	1.009	0.343	0.939	0.830	0.210	0.210
29	1.052	0.0	1.395	0.669	1.436	1.330	0.0	0.0
30	0.759	0.0	0.927	0.0	1.909	1.820	0.0	0.0
31	*****	*****	0.932	0.015	*****	*****	0.0	0.0

DAILY SNOW DEPTH BY ZONE IN CM.M**2(DPTH), DAILY COMPUTED PRECIP CONTRIBUTING TO RUNOFF(CPRE)

RANGO-MARTINEC MODEL FOR DISCHMA BASIN YEAR= 1974

DATA FOR ZONE B

DAY	APR		MAY		JUN		JUL	
	DPTH	CPRE	DPTH	CPRE	DPTH	CPRE	DPTH	CPRE
1	0.0	0.0	0.0	0.0	0.918	0.0	1.990	0.0
2	0.0	0.0	0.0	0.0	0.623	0.128	1.971	0.570
3	0.0	0.0	0.0	0.0	2.985	0.182	1.535	0.0
4	0.816	0.018	0.0	0.0	3.531	0.0	2.130	0.890
5	0.0	0.0	0.0	0.0	3.413	0.0	1.900	0.0
6	0.0	0.0	0.0	0.0	1.450	0.085	1.892	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	1.561	1.030
8	0.0	0.0	0.0	0.0	0.036	0.0	0.490	0.030
9	0.138	0.010	0.0	0.0	0.0	0.0	1.437	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	2.048	0.740
11	0.0	0.0	0.0	0.0	0.0	0.0	1.935	0.210
12	0.0	0.0	0.0	0.0	0.0	0.0	2.329	0.0
13	0.589	0.020	2.473	0.297	0.0	0.0	2.256	0.0
14	0.0	0.0	0.572	0.0	0.641	0.0	1.874	0.200
15	0.0	0.0	0.0	0.0	2.573	0.810	4.426	3.080
16	0.0	0.0	0.673	0.083	2.927	1.204	1.769	0.0
17	0.0	0.0	0.898	0.112	1.764	0.0	1.461	0.520
18	0.0	0.0	1.010	0.131	0.551	0.0	3.211	2.960
19	0.0	0.0	1.672	0.078	0.367	0.0	0.031	0.0
20	0.0	0.0	1.295	0.0	2.214	0.703	0.0	0.0
21	0.0	0.0	1.383	0.038	1.471	0.0	1.288	1.051
22	0.0	0.0	0.706	0.0	2.888	1.410	0.995	0.638
23	0.0	0.0	0.0	0.0	2.434	0.650	0.889	0.0
24	0.0	0.0	0.0	0.0	2.267	1.590	1.245	0.0
25	0.0	0.0	0.0	0.0	1.568	0.090	2.075	1.350
26	0.0	0.0	0.540	0.0	1.665	0.0	0.897	0.170
27	0.0	0.0	1.708	0.299	3.575	2.710	1.163	0.0
28	0.0	0.0	0.570	0.0	1.747	0.830	1.229	0.210
29	0.039	0.0	0.879	0.0	2.190	1.330	1.159	0.0
30	0.0	0.0	2.045	0.389	2.625	1.820	1.104	0.0
31	*****	*****	2.300	0.375	*****	*****	0.899	0.0

Figure 27. (Continued)

DAILY SNOW DEPTH BY ZONE IN CM.M**2(DPTH),　　　DAILY COMPUTED PRECIP CONTRIBUTING TO RUNOFF(CPRE)

RANGO-MARTINEC MODEL FOR DISCHMA BASIN　　　YEAR= 1974

DATA FOR ZONE C

DAY	APR		MAY		JUN		JUL	
	DPTH	CPRE	DPTH	CPRE	DPTH	CPRE	DPTH	CPRE
1	0.0	0.0	0.0	0.0	0.0	0.0	2.544	0.534
2	0.0	0.0	0.0	0.0	0.0	0.0	2.014	0.873
3	0.0	0.0	0.0	0.0	2.313	0.486	1.774	0.373
4	0.0	0.0	0.0	0.0	3.263	0.685	2.053	1.080
5	0.0	0.0	0.0	0.0	3.163	0.677	2.181	0.0
6	0.0	0.0	0.0	0.0	0.422	0.0	2.263	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	1.874	0.233
10	0.0	0.0	0.0	0.0	0.0	0.0	2.221	0.740
11	0.0	0.0	0.0	0.0	0.0	0.0	2.614	0.210
12	0.0	0.0	0.0	0.0	0.0	0.0	3.752	0.0
13	0.0	0.0	1.361	0.265	0.0	0.0	3.682	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	2.734	0.200
15	0.0	0.0	0.0	0.0	1.338	0.288	4.977	3.080
16	0.0	0.0	0.0	0.0	1.998	0.948	2.881	0.0
17	0.0	0.0	0.0	0.0	1.438	0.309	1.643	0.520
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.731	0.146	0.0	0.0	0.0	0.0
20	0.0	0.0	0.394	0.079	1.163	0.250	0.0	0.0
21	0.0	0.0	0.369	0.0	1.138	0.245	0.0	0.0
22	0.0	0.0	0.0	0.0	2.551	1.619	0.009	0.0
23	0.0	0.0	0.0	0.0	2.014	0.650	2.269	0.840
24	0.0	0.0	0.0	0.0	0.0	0.0	3.538	1.044
25	0.0	0.0	0.0	0.0	1.403	0.372	2.513	1.350
26	0.0	0.0	0.0	0.0	1.404	0.060	1.401	0.170
27	0.0	0.0	0.596	0.122	0.265	0.0	2.626	0.0
28	0.0	0.0	0.0	0.0	0.363	0.0	2.620	0.210
29	0.0	0.0	0.0	0.0	0.304	0.0	3.002	0.0
30	0.0	0.0	0.934	0.191	0.247	0.0	2.992	0.0
31	*****	*****	1.022	0.0	*****	*****	2.354	0.0

Figure 27. (Continued)

DAILY COMPUTED AND ACTUAL SNOWMELT RUNOFF DATA

RANGO-MARTINEC MODEL FOR DISCHMA BASIN YEAR= 1974

DAY	APR		MAY		JUN		JUL	
	COMPUTED	ACTUAL	COMPUTED	ACTUAL	COMPUTED	ACTUAL	COMPUTED	ACTUAL
1	0.564	0.600	0.453	0.800	3.941	4.510	7.367	5.620
2	0.571	0.630	0.441	0.760	3.808	3.780	7.323	6.680
3	0.584	0.670	0.421	0.760	4.119	4.020	7.142	6.550
4	0.689	0.710	0.427	0.770	5.116	4.850	7.024	6.230
5	0.786	0.760	0.434	0.720	6.163	5.830	7.026	6.060
6	0.757	0.750	0.414	0.760	6.513	6.330	6.994	6.180
7	0.732	0.800	0.396	0.790	5.900	4.920	6.762	6.200
8	0.716	0.840	0.391	0.870	5.066	3.990	6.140	5.290
9	0.733	0.890	0.396	0.970	4.383	3.630	5.710	5.210
10	0.751	0.950	0.413	1.100	3.801	3.260	5.784	6.610
11	0.737	0.960	0.434	1.140	3.307	2.920	5.992	6.520
12	0.735	0.990	0.440	1.120	2.894	2.670	6.323	6.650
13	0.817	1.070	0.695	1.230	2.548	2.430	6.743	6.840
14	0.873	1.230	1.111	1.470	2.482	2.540	6.950	7.860
15	0.814	1.160	1.153	1.550	2.991	2.840	7.649	8.720
16	0.756	1.010	1.199	1.850	3.879	2.930	8.245	6.600
17	0.705	0.920	1.390	2.200	4.464	3.170	7.910	7.160
18	0.659	0.850	1.619	2.480	4.418	3.670	7.752	7.140
19	0.618	0.810	1.999	2.840	4.122	3.410	7.278	5.340
20	0.581	0.780	2.439	2.930	4.194	3.570	6.234	4.540
21	0.547	0.770	2.784	3.030	4.434	4.110	5.541	4.480
22	0.517	0.770	2.957	3.510	4.980	5.440	5.129	4.120
23	0.492	0.780	2.779	3.270	5.760	5.280	4.872	4.060
24	0.470	0.800	2.455	2.720	6.159	5.590	4.923	4.150
25	0.447	0.760	2.188	2.460	6.240	4.810	5.205	5.080
26	0.426	0.750	2.141	2.400	6.136	5.010	5.258	4.160
27	0.407	0.740	2.493	2.630	6.594	6.100	5.144	4.310
28	0.408	0.740	2.776	2.830	7.015	5.610	5.188	4.530
29	0.433	0.800	2.804	2.700	6.972	5.930	5.250	4.390
30	0.452	0.840	3.111	3.040	7.197	5.610	5.306	4.440
31	*******	*******	3.652	4.050	*******	*******	5.265	4.810

TOTAL ACTUAL STREAMFLOW= 390.2161
MEAN ACTUAL STREAMFLOW= 3.1985

TOTAL COMPUTED VOLUME= 406.6025
MEAN COMPUTED VOLUME= 3.3328

GOODNESS OF FIT MEASURE= 0.9029

PERCENT SEASONAL DIFFERENCE= -4.1993

END OF DATA
READY

Figure 27. (Continued)

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APPENDIX A
DETAILED PROGRAM FLOW CHARTS

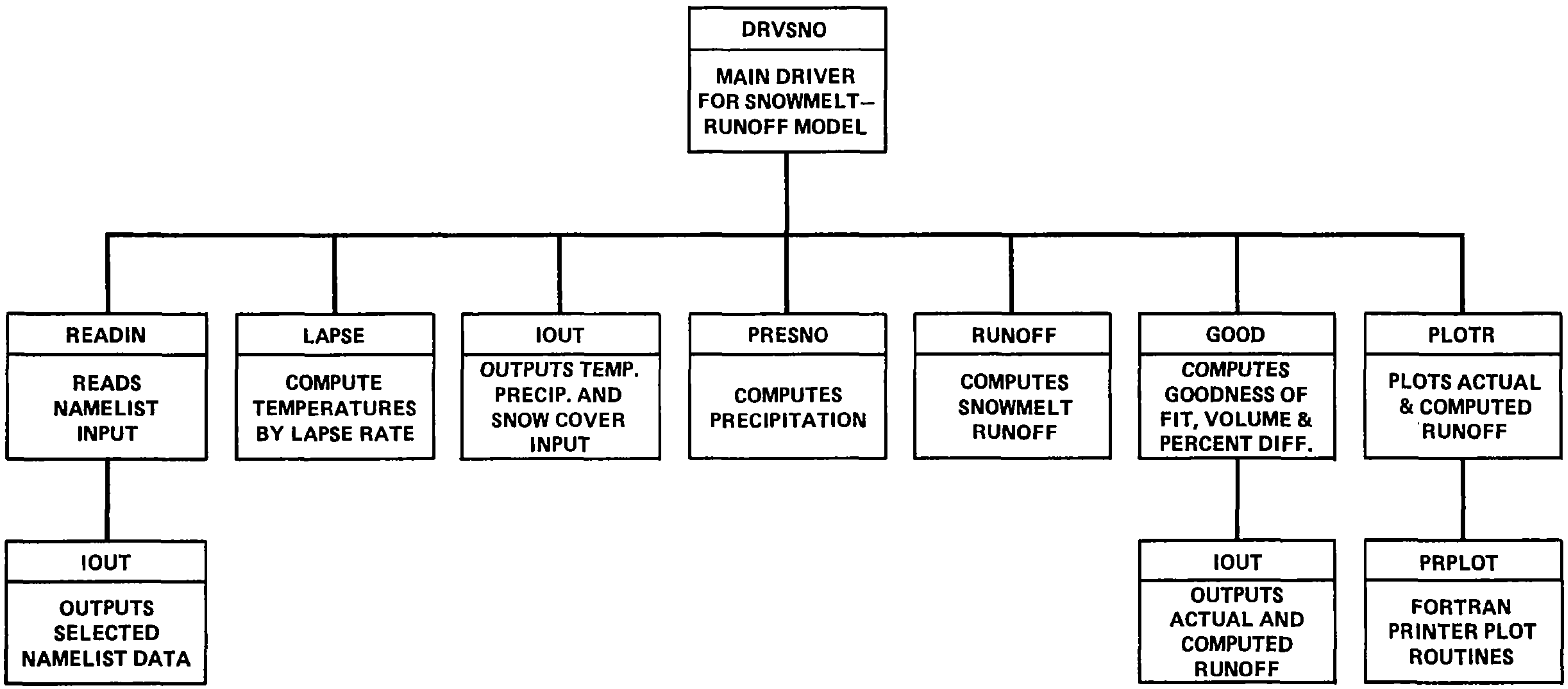


Figure A–1. Flow chart for subroutines of the snowmelt -runoff model program.

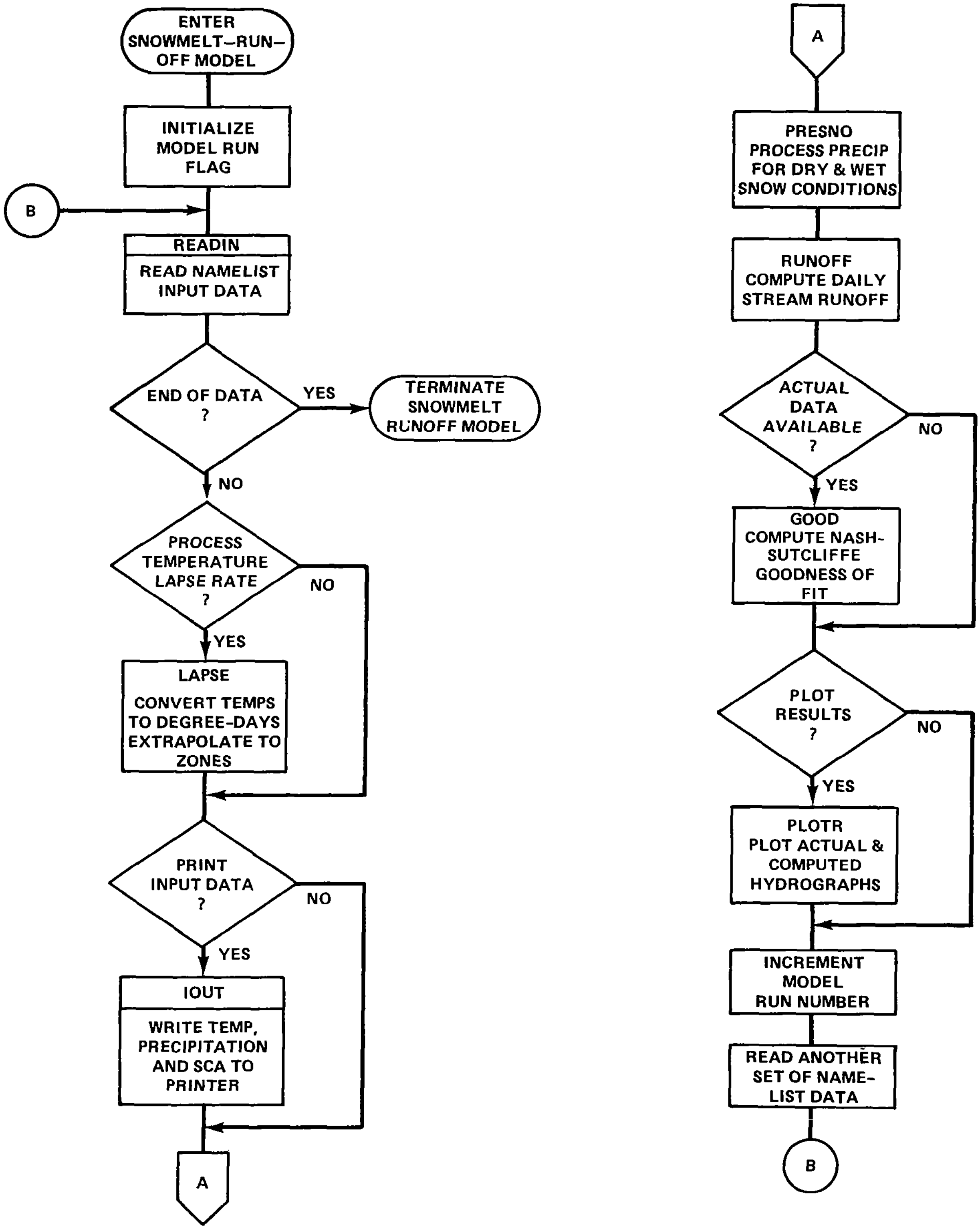


Figure A–2. Flow diagram for DRVSNO, the main component of the snowmelt-runoff model.

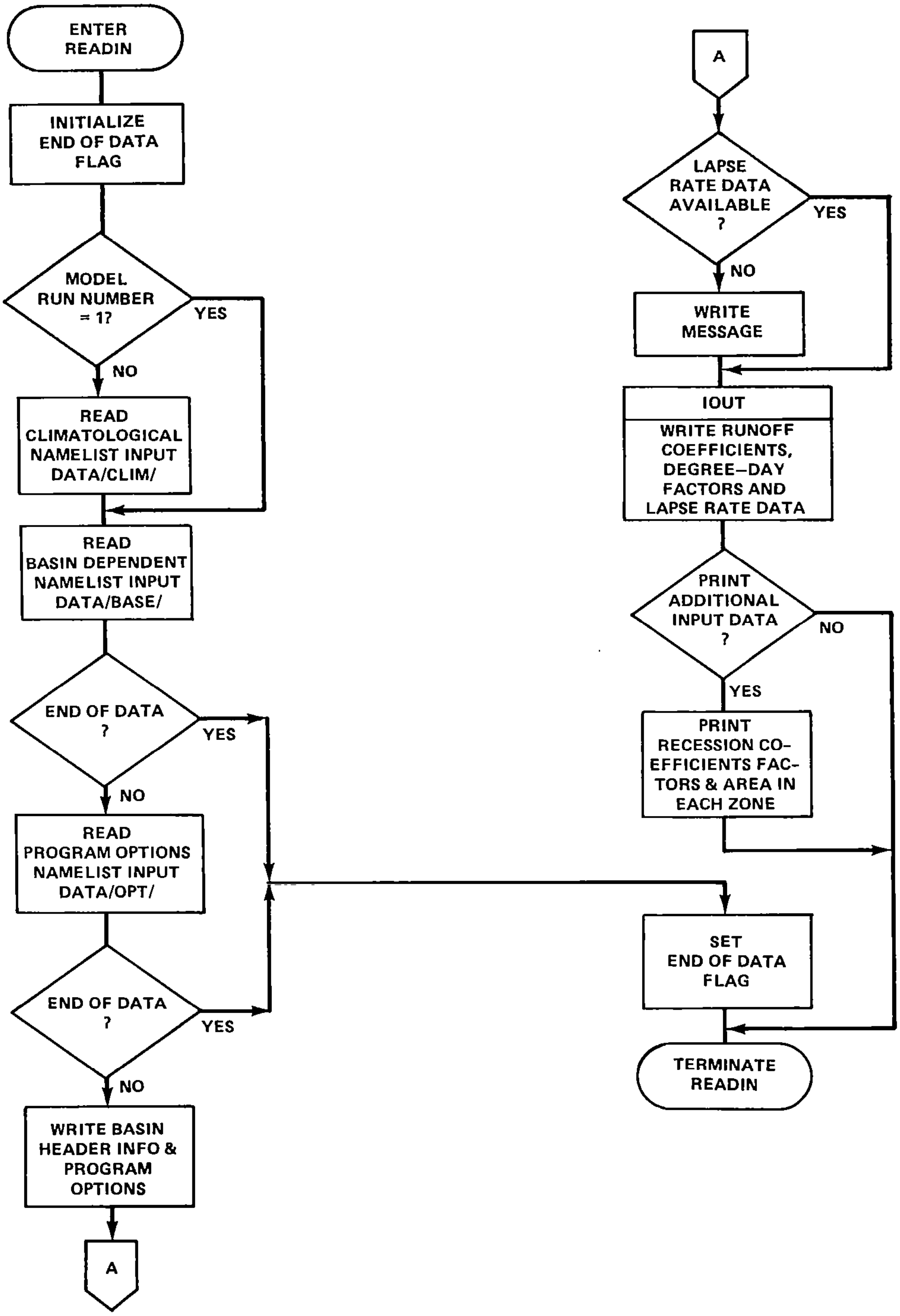


Figure A–3. Flow diagram for subroutine READIN.

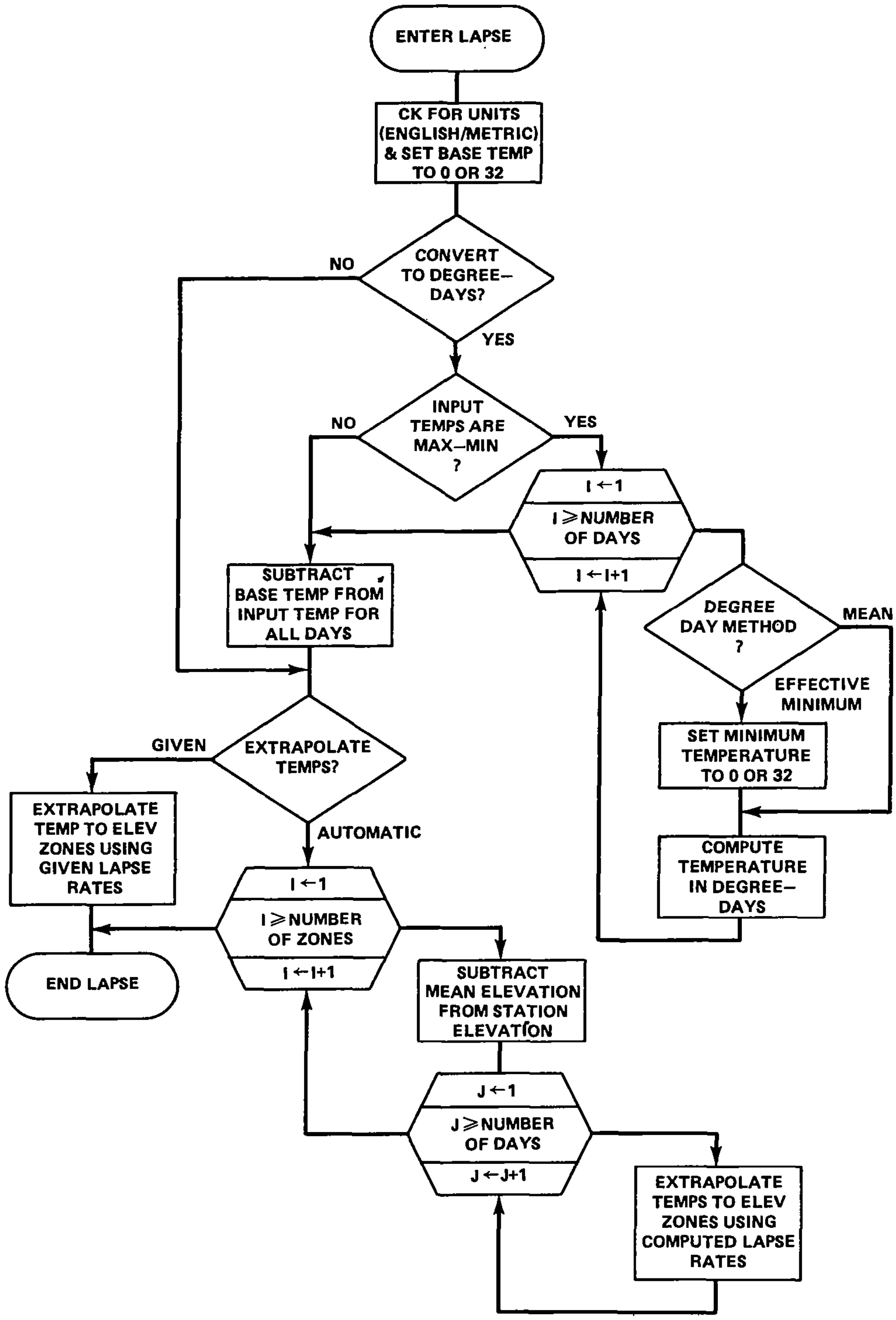


Figure A–4. Flow diagram for subroutine LAPSE.

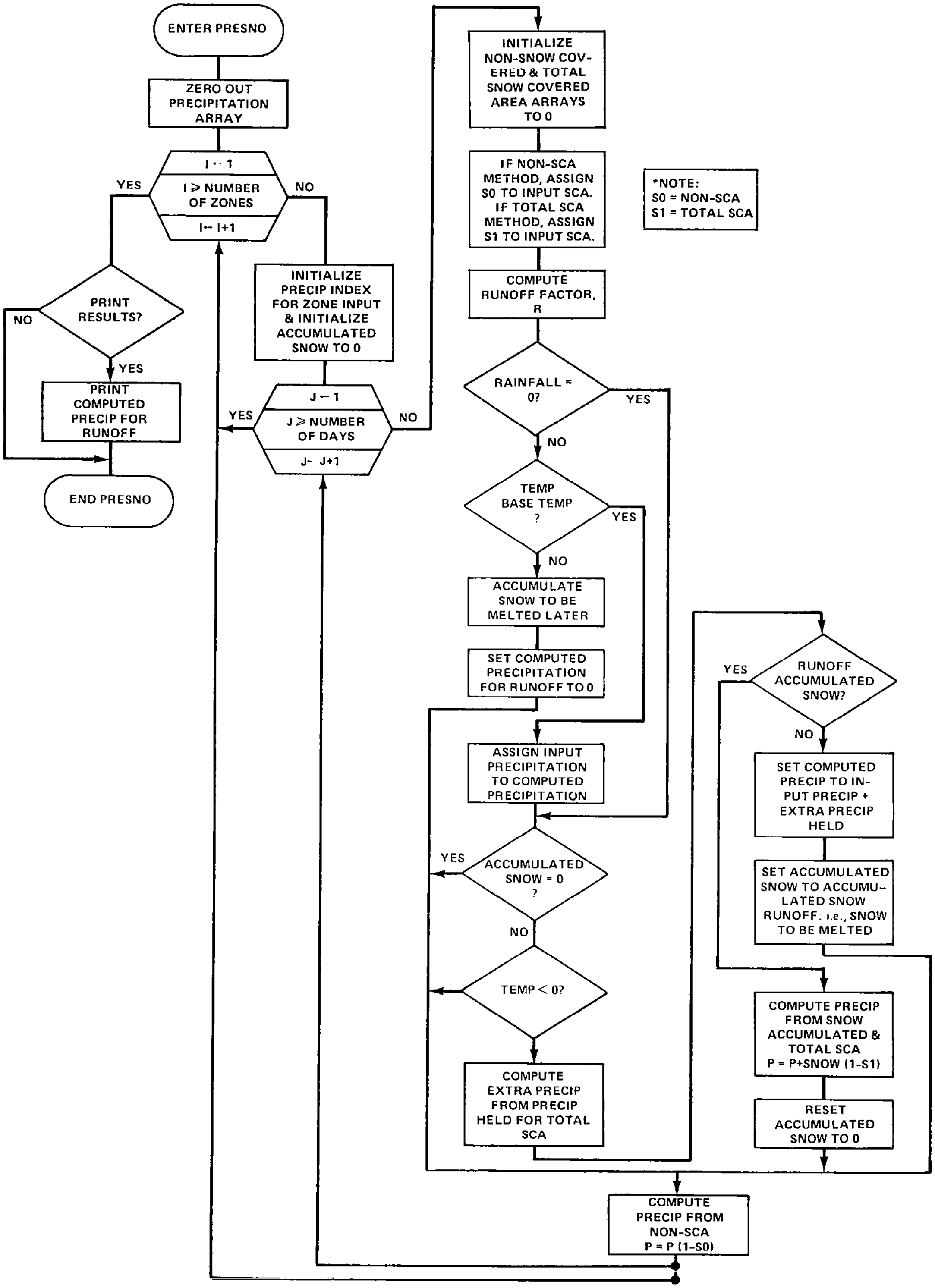


Figure A–5. Flow diagram for subroutine PRESNO.

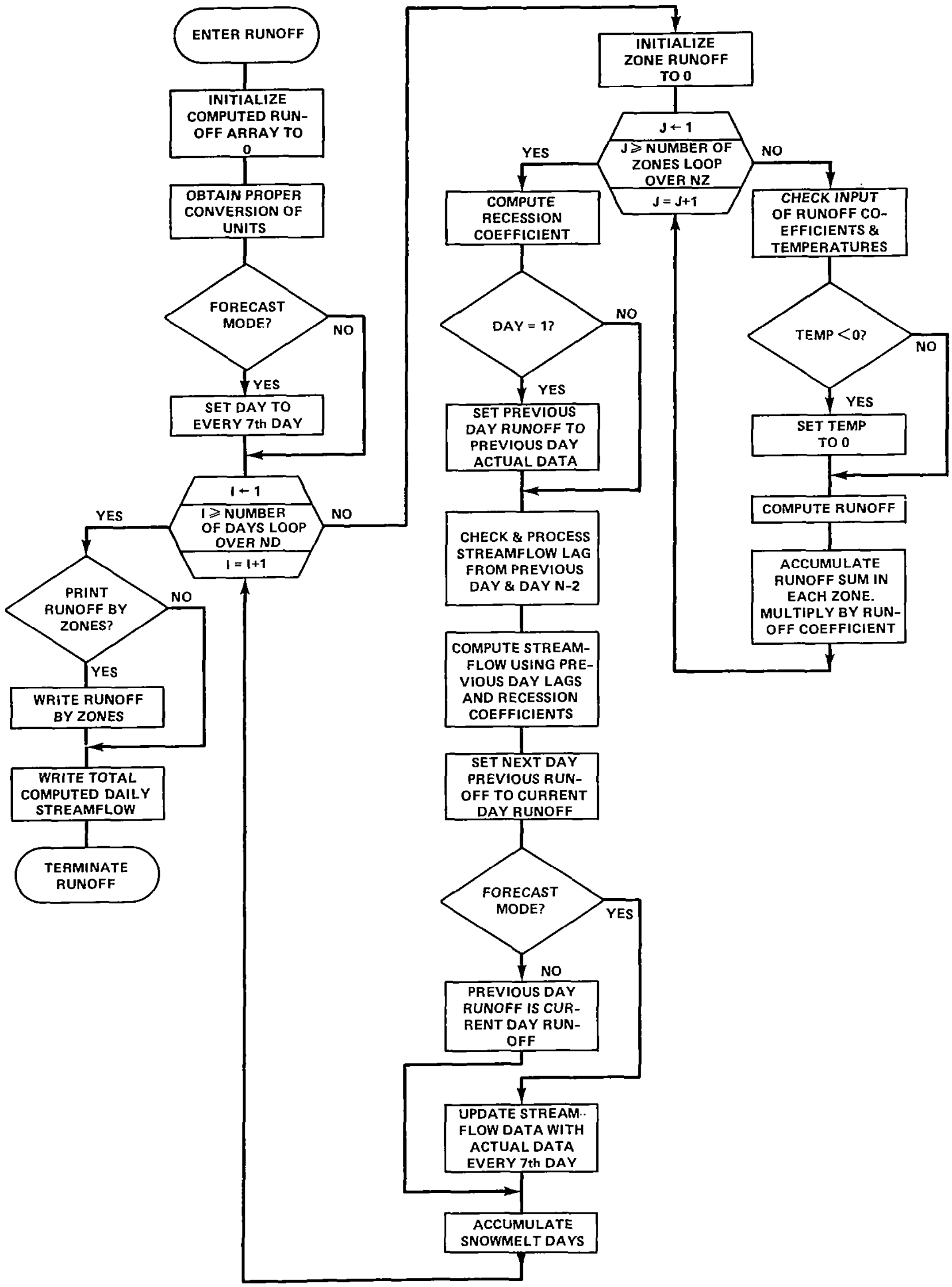


Figure A–6. Flow diagram for subroutine RUNOFF.

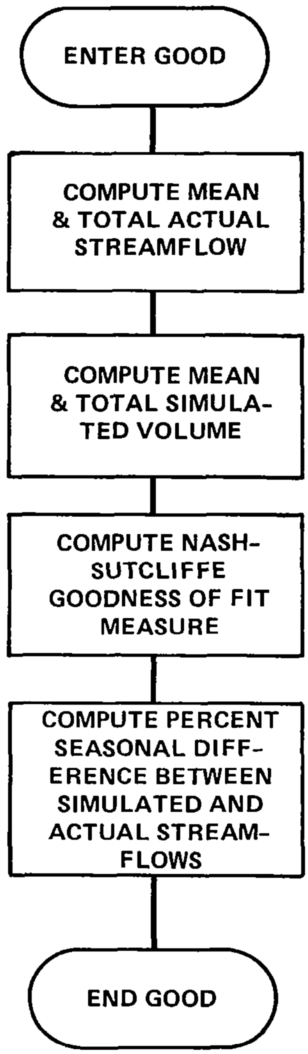


Figure A–7. Flow diagram for subroutine GOOD.

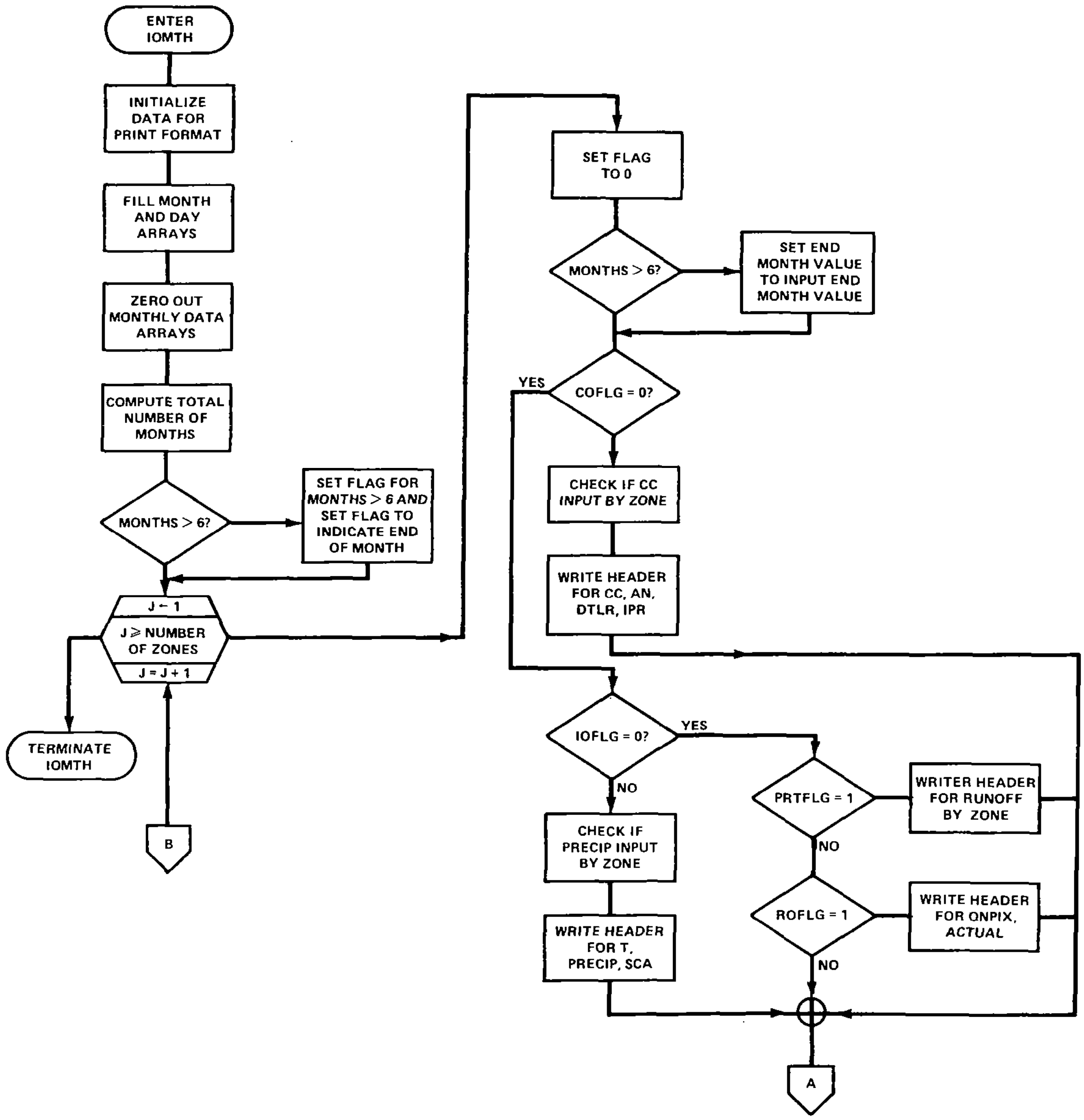


Figure A–8. Flow diagram for subroutine IOMTH.

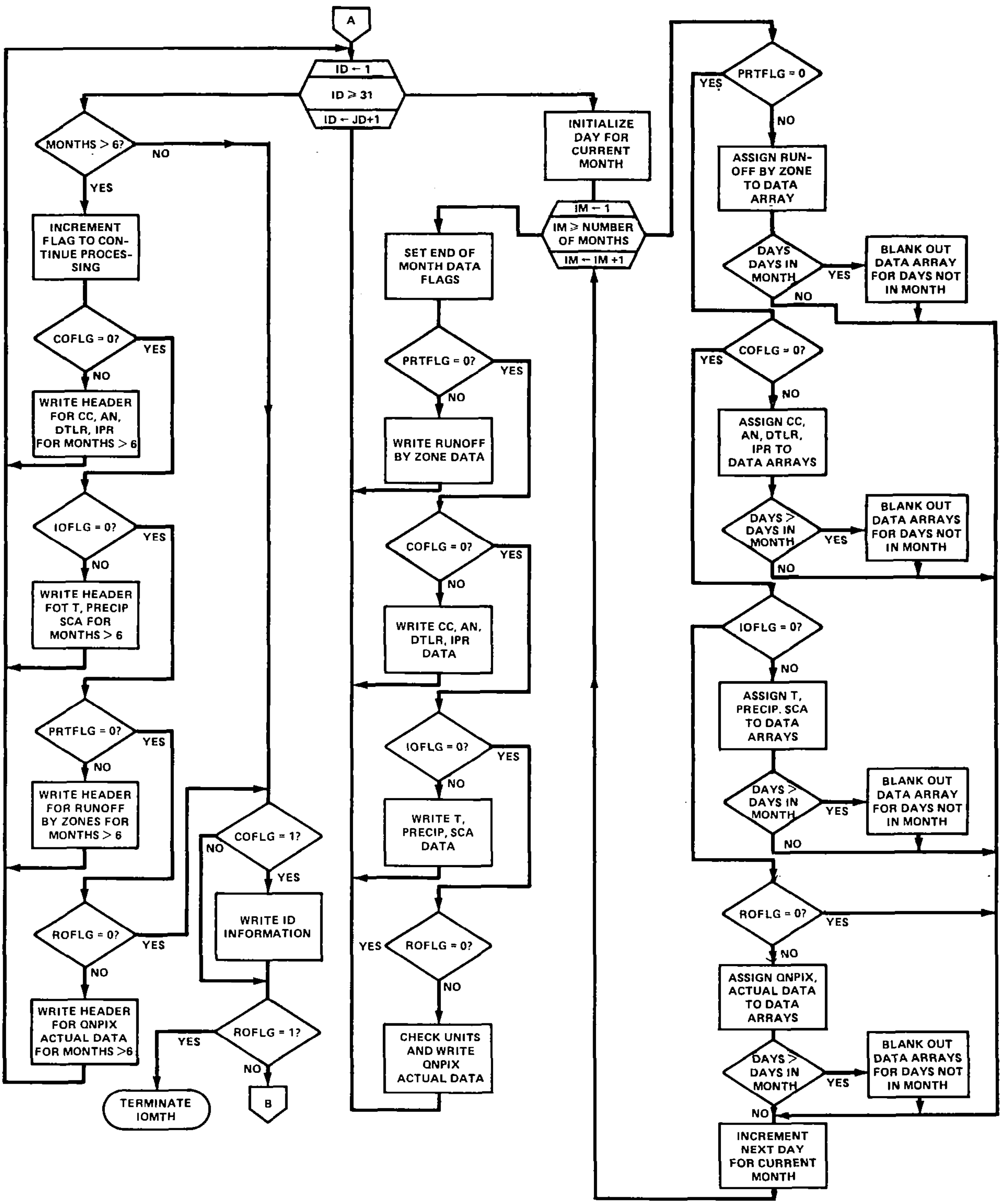


Figure A–8. (Continued)

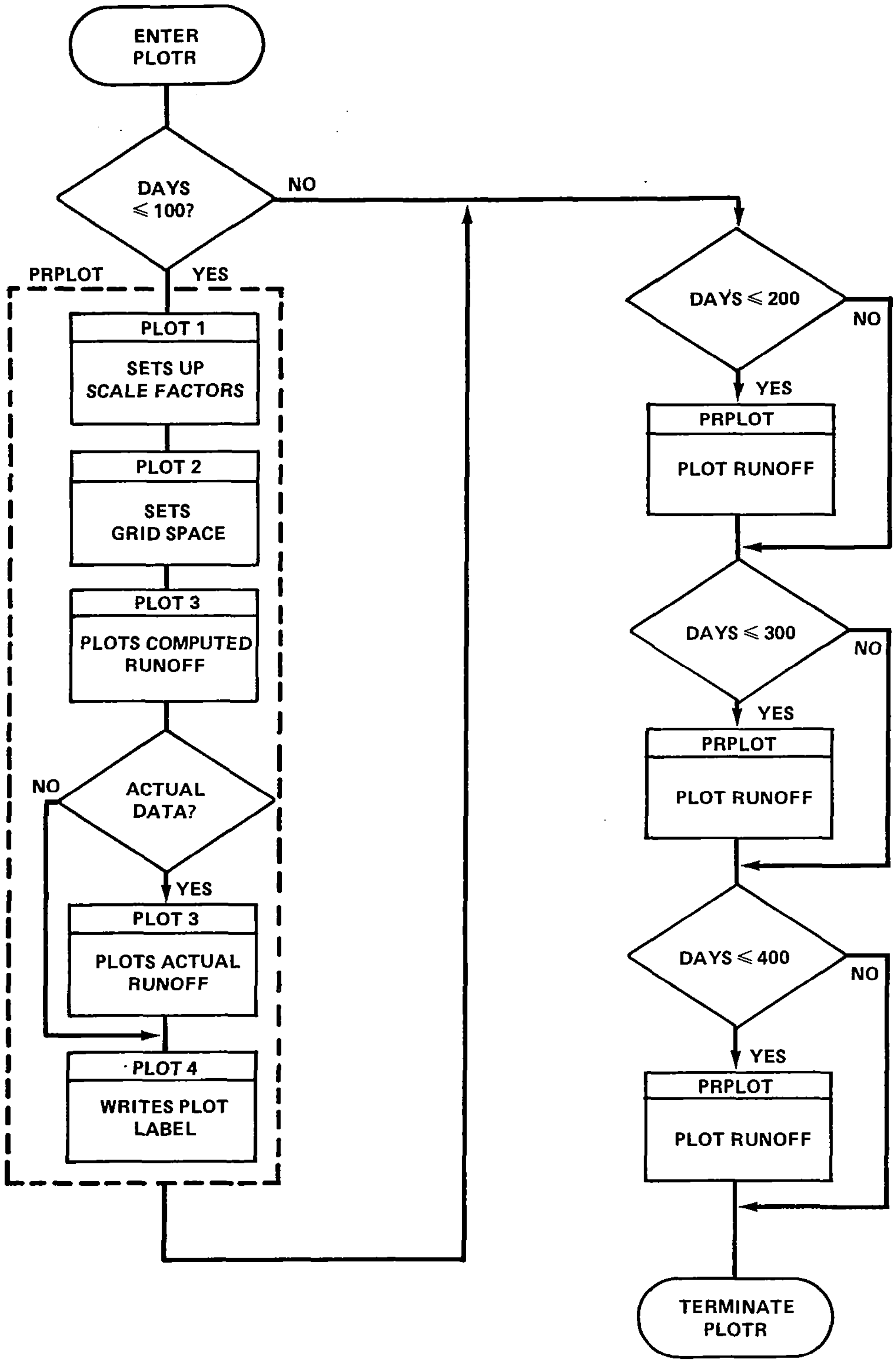
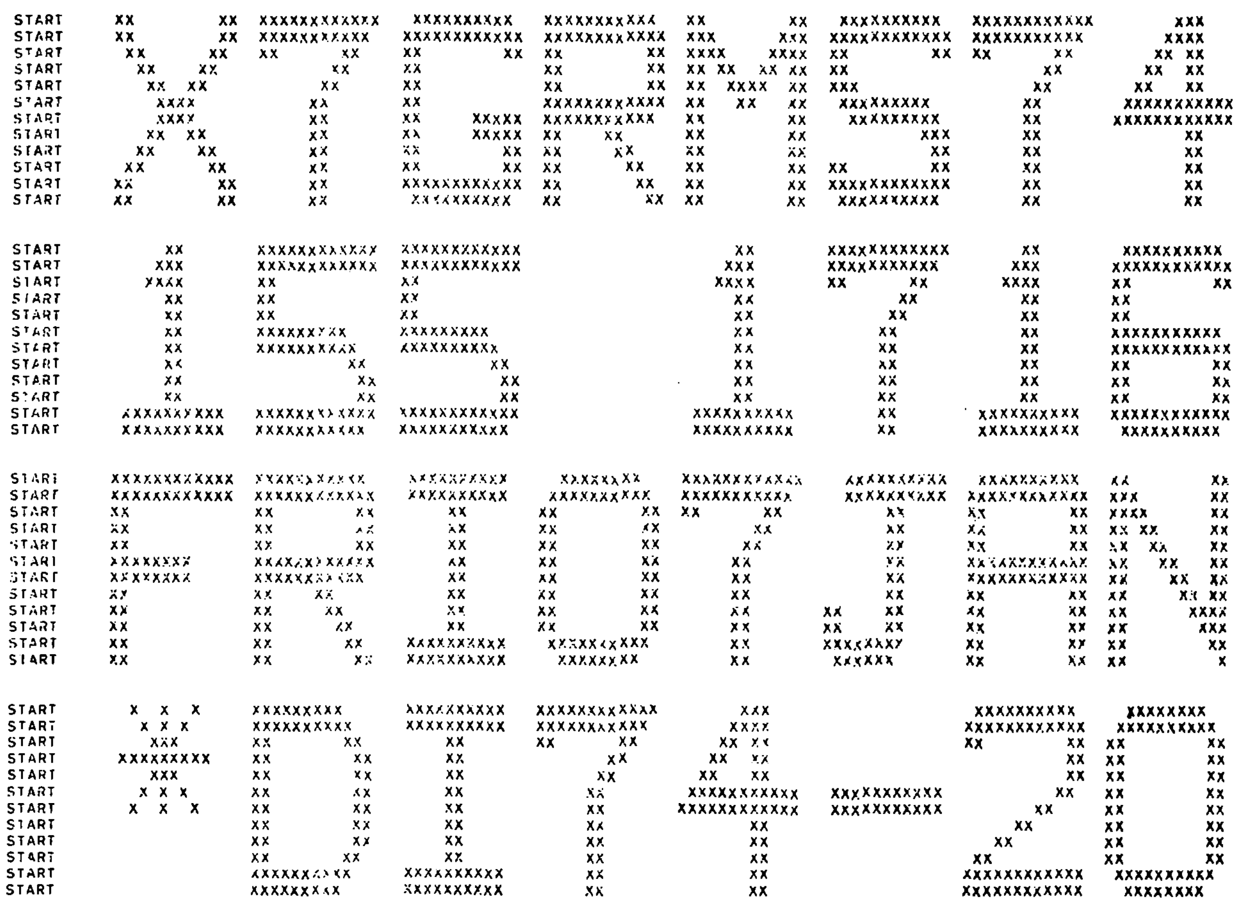


Figure A–9. Flow diagram for subroutine PLOTR.

APPENDIX B

FORTRAN Source Listing for the SRM Program and Subroutine PRPLOT with Compilation on the IBM 3081.



START JOB 1716 X7GRMS74 TAPE1 05:13:26 FRI 07 JAN 83 (83/007) CLASS 6/STD. NASA/GSFC SACC 370/168 HASP II V4.0

```
SNOW.MELT.RUNOFF.MODEL.FORT
      BLOCK DATA
C
C*************************************************************************
C
C         FUNCTION - BLOCK DATA CONTAINS ALL OF THE NAMELIST AND
C                    OUTPUT VARIABLES IN ALL OF THE COMMON BLOCKS
C                    USED IN THE SNOWMELT-RUNOFF MODEL PROGRAM.
C                    DEFAULT VALUES ARE INDICATED WHERE APPLICIBLE
C
C
C
C         COMMON BLOCK VARIABLES
C         VARIABLE     COMMON   TYPE   DEFAULT    DESCRIPTION
C         --------     ------   ----   -------    -----------
C         P            OUTDAT   R*4       -       PRECIPITATION CONTRIBUTING
C                                                 TO RUNOFF IN EACH ELEVATION
C                                                 ZONE(MET:CM;ENG:IN)
C
C         QNP1X        OUTDAT   R*4       -       COMPUTED AVERAGE DAILY
C                                                 STREAM RUNOFF(MET:M**3/SEC;
C                                                 ENG:FT**3/SEC)
C
C         X1           OUTDAT   R*4       -       ARRAY CONTAINING NUMBER OF
C                                                 DAYS FOR PLOT ROUTINE
C
C         TEMPT        OUTDAT   R*4       -       COMPUTED TEMPERATURE IN
C                                                 DEGREE-DAYS
C
C
C
C                      NAMELIST /CLIM/ PARAMETERS
C                      CLIMATOLOGICAL DATA
C
C
C         TMAX         TBASE    R*4       -       MAXIMUM DAILY TEMPERATURES
C                                                 RECORDED FOR BASE STATION
C                                                 (MET:C;ENG:F)
C
C         TMIN         TBASE    R*4       -       MINIMUM DAILY TEMPERATURES
C                                                 RECORDED FOR BASE STATION
C                                                 (MET:C;ENG:F)
C
C         T            CLIDAT   R*4       -       TEMPERATURE DATA EXPRESSED
C                                                 IN DEGREE-DAYS(MET:C-D;
C                                                 ENG:F-D)
C
C         S            CLIDAT   R*4       -       SNOWCOVER AREA IN EACH
C                                                 ELEVATION ZONE(1.0=100%)
C
C         PRECIP       CLIDAT   R*4       -       DAILY MEASURED PRECIPITATION
C                                                 (MET:CM;ENG:IN)
C
C         ACTUAL       CLIDAT   R*4       -       ACTUAL STREAM RUNOFF FROM
C                                                 HISTORICAL DATA
C                                                 (MET:M**3/SEC;ENG:FT**3/SEC)
C
C         TCRIT        CLIDAT   R*4       -       TEMPERATURE CONVERSION
C                                                 FACTOR FOR RAIN/SNOW CHECK
C
C         ND           CLIDAT   I*4      183      NUMBER OF SNOWMELT DAYS
C
C
C                   NAMELIST/BASE/ PARAMETERS
C                   BASIN DATA
C
C         BASIN        BASDAT   R*8               BASIN NAME
C
C         IYEAR        BASDAT   I*4     1979      MODEL YEAR
C
C         NZ           BASDAT   I*4       4       NUMBER OF ELEVATION ZONES
C
C         AREA         BASDAT   R*8       -       AREA IN EACH ELEVATION
C                                                 ZONE(MET:M**2;ENG:FT**2)
C
C         X            BASDAT   R*8    0.884D0    X PARAMETER IN COMPUTING
C                                                 RECESSION COEFFICIENT,K
C
C         Y            BASDAT   R*8   -0.0677D0   Y PARAMETER IN COMPUTING
```

```
C                                                  RECESSION COEFFICIENT,K
C
C      PDR         GAGE      R*4       1.0         PREVIOUS DAY RUNOFF AT
C                                                  STREAM GAGE.
C
C      PDM2        GAGE      R*4       0.0         PREVIOUS DAY-1 RUNOFF AT
C                                                  STREAM GAGE.
C
C      QNS         GAGE      R*8       0.D0        INITIAL RUNOFF VALUE.
C                                                  THIS VALUE SHOULD BE THE
C                                                  ACTUAL DATA VALUE DAY
C                                                  ACTUAL(1)-1.
C
C      DTLR        BASDAT    R*4        -          ADJUSTMENT FOR TEMPERATURE
C                                                  LAPSE RATE(MET:C-D;
C                                                  ENG:F-D)
C
C      AN          BASDAT    R*4        -          DEGREE DAY FACTORS
C                                                  (MET:CM/C/DAY;ENG:IN/F/DAY)
C
C      CS          BASDAT    R*4        -          RUNOFF COEFFICIENTS
C                                                  FOR SNOW
C
C      CR          BASDAT    R*4        -          RUNOFF COEFFICIENTS
C                                                  FOR RAIN
C
C      IPR         BASDAT    I*2        -          PRECIPITATION METHOD OPTION
C                                                  0=NON-SNOW COVERED AREA
C                                                  1=TOTAL AREA
C
C      ZMEAN       TBASE     R*8        -          HYPSOMETRIC MEAN ELEVATION
C                                                  OF EACH ZONE
C
C      STATN       TBASE     R*8        -          ELEVATION OF BASE STATION
C
C      MAXMIN      TBASE     I*2        0          FLAG TO INDICATE IF TEMPS
C                                                  ARE INPUT AS MAX-MIN
C                                                  0=TEMPS NOT AS MAX-MIN
C                                                  1=TEMPS INPUT AS MAX-MIN
C
C      IEXT        TBASE     I*2        0          FLAG IF TEMPERATURES ARE TO
C                                                  BE AUTOMATICALLY EXTRAPOLATED
C                                                  TO ELEVATION ZONE.
C                                                  SINGLE STATION INPUT ONLY.
C                                                  0=EXTRAPOLATE USING GIVEN
C                                                    LAPSE RATES.
C                                                  1=AUTOMATICALLY EXTRAPOLATE
C
C      IDEGDY      TBASE     I*2        1          FLAG IF TEMPERATURE IS TO BE
C                                                  COMPUTED IN DEGREE-DAYS
C                                                  0=NO COMPUTATION NECESSARY-
C                                                    TEMP IS INPUT IN DEGREE-
C                                                    DAYS.
C                                                  1=COMPUTE TEMP. IN DEGREE-
C                                                    DAYS.
C
C
C                  NAMELIST/OPT/ PARAMETERS
C                  PROGRAM CONTROL AND OPTIONS
C
C      IRUN        OPTDAT    I*2        1          RUN SEQUENCE NUMBER
C
C      MODE        OPTDAT    I*2        0          SNOWMELT MODE.
C                                                  0=SIMULATION MODE
C                                                  1=FORECAST MODE
C
C      IPLT        OPTDAT    I*2        1          PLOT OPTION
C                                                  0=NO PLOT
C                                                  1=PLOT
C
C      IPRINT      OPTDAT    I*2        0          PRINT OPTION
C                                                  0=NO PRINT
C                                                  1=PRINT
C
C      UFLAG       OPTDAT    I*2        0          UNITS FLAG
C                                                  0-METRIC UNITS
C                                                  1=ENGLISH UNITS
C
C      ACTFLG      OPTDAT    I*2        1          ACTUAL DATA FLAG
C                                                  0-NO ACTUAL DATA
```

```
C                                              1=ACTUAL DATA
C
C     IZONE      OPTDAT   I*2        3*0  ZONE DATA FLAG
C                                         IZONE(1)=TEMPERATURE LAPSE
C                                         RATE DATA
C                                         IZONE(2)=PRECIPITATION DATA
C                                         IZONE(3)=RUNOFF COEFFICIENTS
C                                         0=NO ZONE DATA AVAILABLE
C                                         1=DATA INPUT BY ZONES
C
C
C     IDTFLG     OPTDAT    I*2       1     TEMPERATURE LAPSE RATE FLAG
C                                          0=NO TEMPERATURE LAPSE RATE
C                                           DATA AVAILABLE
C                                          1=TEMPERATURE LAPSE RATE
C                                            DATA AVAILABLE
C
C     MTHD       OPTDAT    I*2       1    METHOD USED TO COMPUTE
C                                         TEMPERATURE IN DEGREE-
C                                         DAYS IN TEMPERATURE PRE-
C                                         PROCESSING ROUTINE
C                                           0=MEAN METHOD
C                                           1=EFFECTIVE MINIMUM METHOD
C
C     ITPROC     OPTDAT   I*2        1    TEMPERATURE PRE-PROCESSING
C                                         FLAG.
C                                         0=NO PRE-PROCESSING
C                                         1=PREPROCESS TEMPERATURES
C
C     IPRRUN     OPTDAT   I*2        1    PRINT RUNOFF VALUES PER ZONE
C                                          0=NO PRINT
C                                          1=PRINT
C
C     ISTMTH     OPTDAT   I*4        4    INTEGER INDICATING START
C                                         MONTH OF MODEL
C
C     IENMTH     OPTDAT   I*4        4    INTEGER INDICATING END
C                                         MONTH OF MODEL
C
C    EXTERNAL REFERENCES - NONE
C
C    CALLED FROM - NONE
C
C    DESIGNER/PROGRAMMER - G.MAJOR, RESEARCH & DATA SYSTEMS,INC.
C
C    LANGUAGE/COMPUTER - FORTRAN IV/IBM 360/91 AT GSFC
C
C*************************************************************************
C
C
     REAL*8 BASIN,AREA,X,Y,QNS,ZMEAN,STATN
C
     INTEGER*2 IRUN,MODE,IPRRUN,IPLT,IPRINT,UFLAG,ACTFLG,IZONE,
    1  IDTFLG,MTHD,ITPROC,MAXMIN,IEXT,IDEGDY,IPR
C
      NAMELIST CLIMATOLOGICAL DATA COMMONS
C
     COMMON/CLIDAT/T(366,8),S(366,8),PRECIP(366,8),ACTUAL(366),
    1 TCRIT(366),ND
C
     COMMON/TBASE/ZMEAN(8),STATN,TMAX(366),TMIN(366),MAXMIN,IEXT,
    1 IDEGDY
C
      NAMELIST BASIN DATA COMMONS
C
     COMMON/BASDAT/BASIN(2),AREA(8),X,Y,DILR(366,8),AN(366,8),
    1 CS(366,8),CR(366),NZ,IYEAR,IPR(366,8)
C
C
      NAMELIST OPTIONS COMMON
C
     COMMON/OPTDAT/ISTMTH,IENMTH,IRUN,MODE,IPRRUN,IPLT,IPRINT,UFLAG,
    1  ACTFLG,IZONE(3),IDTFLG,MTHD,ITPROC
C
      OUTPUT DATA COMMON
C
     COMMON/OUTDAT/P(366,8),QNP1X(367),X1(367),TEMPT(366,8)
C
      STREAMFLOW LAG AT STREAM GAGE COMMON
C
```

```
      COMMON/GAGE/QNS,PDR(367),PDM2(367)
C
C      DATA STATEMENTS
C
      DATA T/2928*0.0/
      DATA S/2928*0.0/
      DATA PRECIP/2928*0.0/
      DATA ACTUAL/366*0.0/
      DATA TCRIT/366*0./
      DATA ND/183/
      DATA TMAX/366*0./
      DATA TMIN/366*0./
      DATA BASIN/'SOUTH FO','RK       '/
      DATA AREA/1.3D7,2.8D7,9.5D7,9.2D7,4*0.D0/
      DATA X/0.884D0/
      DATA Y/-0.0677D0/
      DATA QNS/0.D0/
      DATA PDR/367*1./
      DATA PDM2/367*0./
      DATA DTLR/2928*0.0/
      DATA AN/2928*0.0/
      DATA CS/2928*0.0/
      DATA CR/366*0./
      DATA NZ/4/
      DATA IYEAR/1979/
      DATA IPR/2928*1/
      DATA ZMEAN/8*0.D0/
      DATA STATN/0.D0/
      DATA MAXMIN/1/
      DATA IEXT/0/
      DATA IDEGRY/1/
      DATA IRUN/1/
      DATA MODE/0/
      DATA IPLT/0/
      DATA IPRINT/0/
      DATA UFLAG/0/
      DATA ACTFLG/1/
      DATA IZONE/3*0/
      DATA IDTFLG/1/
      DATA MTHD/0/
      DATA IIPROC/1/
      DATA IPRRUN/1/
      DATA ISTMTH/4/
      DATA IENMTH/9/
      DATA P/2928*0.0/
      DATA QNP1X/367*0.0/
      DATA X1/367*0.0/
      DATA TEMPT/2928*0./
C
      END
C
C      MAIN PROGRAM FOR SNOWMELT-RUNOFF MODEL(DRVSNO)
C***************************************************************************
C
C      FUNCTION - THIS IS THE MAIN PROGRAM DRIVER FOR THE SNOWMELT-
C                 RUNOFF MODEL PROGRAM AS DEVELOPED BY J.MARTINEC
C                 AND A. RANGO.
C
C      THE SNOWMELT-RUNOFF MODEL PROGRAM COMPUTES THE STREAM RUNOFF
C      FOR ANY MOUNTAINOUS BASIN FOR ANY SNOWMELT SEASON UP TO 365
C      DAYS AND ANY NUMBER OF ELEVATION ZONES UP TO 8 ZONES. THE
C      BASIC INPUT PARAMETERS ARE SNOW COVERED AREA,TEMPERATURE,
C      AND PRECIPITATION DATA. THE DATA MAY BE INPUT FOR EACH ZONE
C      AND MAY BE INPUT IN EITHER METRIC OR ENGLISH UNITS.
C      THE SNOWMELT-RUNOFF MODEL PROGRAM CAN BE OPERATED IN EITHER
C      A SIMULATION MODE WHERE THE COMPUTED STREAM RUNOFF IS COMPARED
C      TO ACTUAL STREAM RUNOFF(IF AVAILABLE) OR A FORCAST MODE WHERE
C      THE STREAM RUNOFF IS COMPARED TO ACTUAL RUNOFF EVERY 7TH DAY.
C
C      INPUT PARAMETERS ARE READ INTO THE PROGRAM FROM THREE NAMELISTS,
C      /CLIM/ CONTAINING CLIMATOLOGICAL DATA,/BASE/ CONTAINING BASIN
C      DEPENDENT DATA, AND /OPT/ CONTAINING PROGRAM OPTIONS.
C
C     AS AN OPTION ALL INPUT PARAMETERS CAN BE REPRODUCED AS OUTPUT
C     ON A MONTHLY BASIS. ALSO AS AN OPTION A PRINTER PLOT CAN BE
C     PRODUCED WITH COMPUTED STREAMFLOW AND ACTUAL STREAMFLOW PLOTTED
C     AS DISCHARGE RATE VS. NUMBER OF DAYS. A 'GOODNESS OF FIT' MEASURE
C     AND TOTAL ACTUAL AND SIMULATED STREAMFLW IS PRODUCED AS OUTPUT
C
C
C
C
C      EXTERNAL REFERENCES--
C        READIN - READS IN NAMELIST AND OTHER INPUT DATA
C        PRETMP - EXTRAPOLATES TEMPERATURES TO ELEVATION ZONE AND
C                 COMPUTES TEMPERATURES IN DEGREE-DAYS.
C        PRESNO - CALCULATES PRECIPITATION CONTRIBUTING TO RUNOFF
C                 FOR EACH ELEVATION ZONE IN BASIN  FROM DRY
C                 SNOW (NON-SNOW COVERED AREA) OR RIPE SNOW (TOTAL
C                 AREA) CONDITIONS.
```

```
C          RUNOFF - COMPUTES THE PREDICTED STREAM RUNOFF BASED ON THE
C                   SNOWMELT-RUNOFF MODEL EQUATIONS BY RANGO AND MARTINEC
C          GOOD   - CALCULATES THE NASH-SUTCLIFFE GOODNESS OF FIT MEASURE
C                   AND COMPUTES THE MEAN ACTUAL STREAMFLOW, PREDICTED
C                   SEASONAL VOLUME AND PER CENT SEASONAL DIFFERENCE
C                   BETWEEN ACTUAL AND PREDICTED STREAMFLOW
C          PLOTR  - CONTAINS PLOT ROUTINES FROM THE FORTRAN PRPLOT
C                   PACKAGE TO PLOT ACTUAL AND PREDICTED STREAMFLOW
C          IOUT   - UTILITY PROGRAM TO OUTPUT RESULTS IN MONTHLY AND
C                   DAILY FORMAT.
C
C       CALLED FROM:
C           NOTHING - THIS IS THE MAIN DRIVER
C
C       LANGUAGE/COMPUTER - FORTRAN IV/IBM 360/91 AT GSFC
C
C       DESIGNER/PROGRAMMER - G.MAJOR, RESEARCH & DATA SYSTEMS,INC.
C
C       REFERENCE - RANGO,A. AND MARTINEC,J. (1979) APPLICATION OF A
C                       SNOWMELT-RUNOFF MODEL USING LANDSAT DATA,
C                       NORDIC HYDROLOGY,VOL.10.
C
C*************************************************************************
C
C
      REAL*8 BASIN,AREA,X,Y,QNS,ZMEAN,STATN
C
      INTEGER*2 IRUN,MODE,IPRRUN,IPLT,IPRINT,UFLAG,ACTFLG,IZONE,
     1 IDFLG,MTHD,ITPROC,MAXMIN,IEXT,IDEGDY,IPR,IOFLG,ROFLG,
     2 COFLG,DTFLG,IOFLG,POFLG
C
      DIMENSION RUNOF(366,8)
C
C***** COMMON BLOCKS ******
C
      COMMON/CLIDAT/T(366,8),S(366,8),PRECIP(366,8),ACTUAL(366),
     1 TCRIT(366),ND
C
      COMMON/TBASE/ZMEAN(8),STATN,TMAX(366),TMIN(366),MAXMIN,IEXT,
     1  IDEGDY
C
      COMMON/OUTDAT/P(366,8),QNEIX(367),X1(367),TEMPT(366,8)
C
      COMMON/BASDAT/BASIN(2),AREA(8),X,Y,DTLR(366,8),AN(366,8),
     1 CS(366,8),CR(366),NZ,IYEAR,IPR(366,8)
C
      COMMON/OPTDAT/ISTMTH,IENMTH,IRUN,MODE,IPRRUN,IPLT,IPRINT,UFLAG,
     1  ACTFLG,IZONE(3),IDFLG,MTHD,ITPROC
C
      COMMON/GAGE/QNS,PDR(367),PDR2(367)
C
C
C***************************
      DATA RUNOF/2928*0.0/
C
C
C       READ INPUT DATA -- CALL READIN
C
C
      ISET=0
   10 CALL READIN(ISET,IEND)
C
C       IF END OF DATA THEN TERMINATE PROGRAM
C
      IF(IEND.GT.0) GO TO 30
C
C     CALL TEMPERATURE PRE-PROCESSING ROUTINE IF DESIRED -- CALL PRETMP
C
      IF(ITPROC.EQ.1) CALL LAPSE(STATN,ND,NZ,MAXMIN,TEMPT,TMAX,TMIN,
     1 DTLR,UFLAG,MTHD,ZMEAN,IEXT,IDEGDY,T)
C
      IF(IPRINT.EQ.0) GO TO 100
C
C       PRINT TEMPERATURE(IN DEGREE-DAYS),PRECIPITATION,AND SNOW
C       COVERED AREA ON MONTHLY AND ZONAL BASIS --- CALL IOUT
C
      IOFLG=1
      ROFLG=0
      COFLG=0
      DTFLG=0
      TOFLG=0
      POFLG=0
C
      IF(ITPROC.EQ.1) GO TO 50
      DO 51 I=1,NZ
        DO 52 J=1,ND
          TEMPT(J,I)=T(J,I)
   52   CONTINUE
   51 CONTINUE
C
   50 CALL IOUT(NZ,BASIN,IYEAR,IZONE,ISTMTH,IENMTH,TEMPT,PRECIP,S,
```

```
     1 IPR,RUNOF,QNP1X,ACTUAL,CS,AN,DTLR,UFLAG,IOFLG,ROFLG,COFLG,
     2 DTFLG,TMAX,TMIN,TCRIT,CR,P,TOFLG,POFLG)
C
C
 100   CONTINUE
C
C      CALL ROUTINE TO COMPUTE PRECIPITATION CONTRIBUTING TO RUNOFF
C
      CALL PRESNO
C
C      COMPUTE PREDICTED RUNOFF -- CALL RUNOFF
C
      CALL RUNOFF
C
C      CHECK IF ACTUAL DATA AVAILABLE
C
      IF(ACTFLG.EQ.0) GO TO 900
C
C      COMPUTE RESULTS -- CALL GOOD
C
C
      CALL GOOD(QNP1X,ACTUAL,ND)
C
 900  CONTINUE
C
C      CHECK IF PLOT IS DESIRED AND CALL PLOT ROUTINE --CALL PLOT
C
      IF(IPLT.EQ.0) GO TO 20
C
      CALL PLOTR(QNP1X,ACTUAL,X1,ND,UFLAG,ACTFLG)
C
  20  CONTINUE
C
C      CHECK IF NOT FIRST RUN AND SET FIRST RUN FLAG,ISET
C
      ISET=ISET+1
C
C
      GO TO 10
  30  WRITE(6,1500)
1500  FORMAT(' END OF DATA')
C
      STOP
      END
      SUBROUTINE READIN(ISET,IEND)
C
C**********************************************************************
C       FUNCTION - READS INPUT DATA FROM NAMELISTS /CLIM/,/BASE/,
C                  AND /OPT/. ALSO OUTPUTS HEADER INFORMATION
C                  AND,ON OPTION,WILL REPRODUCE ALL INPUT PARAMETERS.
C
C
C       ARGUMENT LIST -
C       VARIABLE  TYPE  IO   DESCRIPTION
C       --------  ----  --   -----------
C       ISET      I*4    I   FLAG TO INDICATE FIRST RUN OF MODEL
C       IEND      I*4    O   FLAG TO INDICATE END OF DATA
C
C       COMMON BLOCK VARIABLES USED -
C       VARIABLE  COMMON  TYPE  IO
C       --------  ------  ----  --
C       AREA      BASDAT  R*8   I
C       X         BASDAT  R*8   I
C       Y         BASDAT  R*8   I
C       T         CLIDAT  R*4   I
C       S         CLIDAT  R*4    O
C       PRECIP    CLIDAT  R*4   I
C       ACTUAL    CLIDAT  R*4   I
C       CS        BASDAT  R*4   I
C       DTLR      BASDAT  R*4    O
C       AN        BASDAT  R*4    O
C       ND        BASDAT  I*4   I
C       PDR       GAGE    R*4   I
C       PDM2      GAGE    R*4   I
C       QNS       GAGE    R*8   I
C       NZ        CLIDAT  I*4   I
C       IRUN      OPTDAT  I*4   I
C       MODE      OPTDAT  I*4   I
C       BASIN     BASDAT  R*8   I
C       IPLT      OPTDAT  I*2   I
C       IPRINT    OPTDAT  I*2   I
C       UFLAG     OPTDAT  I*2   I
C       IZONE     OPTDAT  I*2   I
C       IDTFLG    OPTDAT  I*2   I
C       TMAX      TBASE   R*4   I
C       TMIN      TBASE   R*4   I
C       ZMEAN     TBASE   R*8   I
C       STATN     TBASE   R*8   I
C       MAXMIN    TBASE   I*2   I
C       MTHD      OPTDAT  I*2   I
```

```
C        ITPROC    OPTDAT  I*2    I
C
C
C
C        EXTERNAL REFERENCES--
C            IOUT    - UTILITY ROUTINE TO OUTPUT RESULTS IN MONTHLY
C                      AND DAILY FORMAT.
C
C
C        CALLED BY -- MAIN
C
C        COMPUTER/LANGUAGE -- IBM 360 AT GSFC/FORTRAN IV
C
C        DESIGNER/PROGRAMMER -- G.MAJOR,RESEARCH & DATA SYSTEMS,INC.
C
C**********************************************************************
C
         REAL*8 BASIN,AREA,X,Y,QNS,ZMEAN,STATN,UNITS(2),UNIT
C
        INTEGER*2 IRUN,MODE,IPRRUN,IPLT,IPRINT,UFLAG,ACTFLG,IZONE,
     1  IDTFLG,MTHD,ITPROC,MAXMIN,IEXT,IDEGDY,IPR,IOFLG,ROFLG,
     2  COFLG,DTFLG,TOFLG,POFLG
C
        DIMENSION RUNOF(366,8),TEMPT(366,8),AMUNIT(3),AEUNIT(3)
C
        DATA RUNOF/2928*0.0/
        DATA TEMPT/2928*0./
         DATA UNITS/'METERS  ','FEET    '/
         DATA AMUNIT/'SQ. ','METE','RS  '/
         DATA AEUNIT/'SQ. ','MILE','S   '/
C
C****** COMMON BLOCKS ******
C
        COMMON/CLIDAT/T(366,8),S(366,8),PRECIP(366,8),ACTUAL(366),
     1  TCRIT(366),ND
C
        COMMON/TBASE/ZMEAN(8),STATN,TMAX(366),TMIN(366),MAXMIN,IEXT,
     1  IDEGDY
C
C
        COMMON/OPTDAT/ISTMTH,IENMTH,IRUN,MODE,IPRRUN,IPLT,IPRINT,UFLAG,
     1  ACTFLG,IZONE(3),IDTFLG,MTHD,ITPROC
C
        COMMON/BASDAT/BASIN(2),AREA(8),X,Y,DTLR(366,8),AN(366,8),
     1 CS(366,8),CR(366),NZ,IYEAR,IPR(366,8)
C
C
        COMMON/GAGE/QNS,PDR(367),PDM2(367)
C
C
C****************************
C
C
C
C****** INPUT NAMELIST ********
C
C        CLIMATOLOGICAL NAMELIST PARAMETERS
C
        NAMELIST/CLIM/ND,T,S,ACTUAL,PRECIP,TMAX,TMIN,TCRIT
C
C        BASIN NAMELIST PARAMETERS
C
        NAMELIST/BASE/BASIN,NZ,IYEAR,AREA,X,Y,QNS,PDR,PDM2,DTLR,AN,CS,
     1 CR,ZMEAN,STATN,MAXMIN,IEXT,IDEGDY,IPR
C
C        PROGRAM OPTION NAMELIST PARAMETERS
C
        NAMELIST/OPT/IRUN,MODE,IPLT,IPRINT,UFLAG,ACTFLG,IZONE,IDTFLG,
     1  MTHD,ITPROC,IPRRUN,ISTMTH,IENMTH
C
C
C
C
        IEND=0
C
C        CHECK IF NOT FIRST RUN
C
C
        IF(ISET.GE.1) GO TO 10
C
C        READ CLIM NAMELIST FOR CLIMATOLOGICAL DATA
C
        READ(5,CLIM,END=995)
  995    CONTINUE
C
C
C        READ BASE AND OPT NAMELIST FOR BASIN AND PROGRAM OPTION DATA
C
   10   READ(9,BASE,END=999)
        READ(9,OPT,END=999)
```

```
        IF(UFLAG.EQ.0) UNIT=UNITS(1)
        IF(UFLAG.EQ.1) UNIT=UNITS(2)
C
C       WRITE RUN NUMBER AND BASIN NAME
C
      WRITE(6,1500)
C
      WRITE(6,2000) IRUN,BASIN,IYEAR
C
C       WRITE SNOWMELT RUNOFF PROGRAM MODE
C
      WRITE(6,2500) MODE
C
C       WRITE PROGRAM OPTIONS
C
      WRITE(6,3000)
3000  FORMAT(// PROGRAM OPTIONS (0=OFF,1=ON)'//)
      WRITE(6,3500) IPLT,IPRINT,UFLAG,ACTFLG,(IZONE(I),I=1,3),IDTFLG,
     1 MTHD,ITPROC,IPRRUN,IFXT,IDEGDY,MAXMIN,ISTMTH,IENMTH
C
C
C       WRITE NUMBER OF SNOWMELT DAYS AND ELEVATION ZONES
C
      WRITE(6,5000) ND,NZ
C
C       WRITE RECESSION COEFFICIENT FACTORS X AND Y
C
        IF(PDR(1).EQ.0.5) LAG=6
        IF(PDR(1).EQ.0.7) LAG=10
        IF(PDR(1).EQ.0.75) LAG=12
        IF(PDR(1).EQ.0.8) LAG=15
        IF(PDR(1).EQ.1.0) LAG=18
      WRITE(6,6000) X,Y,QNS,LAG
C
C       WRITE AREA IN EACH ELEVATION ZONE
C
        IF(UFLAG.EQ.0) WRITE(6,6500) AMUNIT
        IF(UFLAG.EQ.1) WRITE(6,6500) AEUNIT
      WRITE(6,7000) (I,AREA(I),I=1,NZ)
C
C       WRITE HYPSOMETRIC MEAN ELEVATION IN EACH ZONE
C
      WRITE(6,6900) UNIT
      WRITE(6,7000) (I,ZMEAN(I),I=1,NZ)
C
C
C       WRITE BASE STATION ELEVATION
C
      WRITE(6,7600) UNIT
      WRITE(6,7700) STATN
C
C       CHECK IF LAPSE RATE DATA IS PROVIDED
C
      IF(IDTFLG.EQ.0) WRITE(6,5500)
C
C       WRITE INPUT DATA IF IPRINT DATA FLAG IS SET
C
      IF(IPRINT.EQ.0) GO TO 900
       IF(MAXMIN.EQ.0) GO TO 910
C
      IOFLG=0
      ROFLG=0
      COFLG=0
      DTFLG=0
      TOFLG=1
      POFLG=0
      CALL IOUT(NZ,BASIN,IYEAR,IZONE,ISTMTH,IENMTH,TEMPT,PRECIP,S,
     1 IPR,RUNOF,QNP1X,ACTUAL,CS,AN,DTLR,UFLAG,IOFLG,ROFLG,COFLG,
     2 DTFLG,TMAX,TMIN,TCRIT,CR,P,TOFLG,POFLG)
C
C       WRITE RUNOFF COEFFICIENTS,DEGREE DAY FACTORS AND PRECIPITATION
C       METHOD ON MONTHLY AND ZONAL BASIS
C
 910  IOFLG=0
      ROFLG=0
      COFLG=1
      DTFLG=0
      TOFLG=0
      POFLG=0
      CALL IOUT(NZ,BASIN,IYEAR,IZONE,ISTMTH,IENMTH,TEMPT,PRECIP,S,
     1 IPR,RUNOF,QNP1X,ACTUAL,CS,AN,DTLR,UFLAG,IOFLG,ROFLG,COFLG,
     2 DTFLG,TMAX,TMIN,TCRIT,CR,P,TOFLG,POFLG)
C
C
C       WRITE LAPSE RATE AND CRITICAL TEMPERATURE VALUES
C
      IOFLG=0
      ROFLG=0
      COFLG=0
      DTFLG=1
```

```
      POFLG=0
      TOFLG=0
      CALL IOUT(NZ,BASIN,IYEAR,IZONE,ISTMTH,IENMTH,TEMPT,PRECIP,S,
     1 IPR,RUNOF,QNPIX,ACTUAL,CS,AN,DTLR,UFLAG,IOFLG,ROFLG,COFLG,
     2 DTFLG,TMAX,TMIN,ICRIT,CR,P,TOFLG,POFLG)
      GO TO 900
C
C      SET END FLAG
C
  999 IEND=1
C
C
  900  RETURN
 1500 FORMAT('1',///////)
 2000 FORMAT(//5X,'RUN #',I5,2X,'BASIN=',2A8,2X,'YEAR=',I5/)
 2500 FORMAT(//' MODE (0=SIMULATED,1==FORCAST)=',I3//)
 3500 FORMAT(' PLOT OPTION=',I2,2X,'PRINT OPTION=',I2,2X,'UNITS(0=',
     1 'METRIC,1=ENGLISH)=',I2//1X,'ACTUAL DATA FLAG=',I2,2X,'ZONE ',
     2 'INPUT DATA(TEMP.,PRECIP.,RUNOFF COFF.)=',3I2//
     3 1X,'LAPSE RATE DATA FLAG=',I2,2X,'DEGREE-DAY METHOD(0=MEAN,',
     4 '1=EFFECTIVE MINIMUM)=',I2//
     5 1X,'TEMPERATURE PROCESSING FLAG=',I2,2X,'RUNOFF BY ZONE OUTPUT',
     6 ' OPTION=',I2//
     7 1X,'FLAG TO EXTRAPOLATE TEMPERATURES(0=EXTRAPOLATE USING',
     8 1X,'GIVEN LAPSE RATES, 1=AUTOMATICALLY EXTRAPOLATE)=',I2//
     9 1X,'FLAG TO COMPUTE DEGREE-DAYS=',I2//
     A 1X,'FLAG TO INDICATE INPUT TEMPS ARE MAX-MIN=',I2//
     B 1X,'START MONTH=',I2,2X,'END MONTH=',I2//)
 5000 FORMAT(//' NUMBER OF SNOWMELT DAYS=',I5,5X,'NUMBER OF ',
     1 'ELEVATION ZONES=',I5//)
 5500 FORMAT(/5X,'NO TEMPERATURE LAPSE RATE DATA INPUT'/)
 6000 FORMAT(//5X,'RECESSION COEFFIECIENT FACTORS'//' X FACTOR=',
     1 F9.6,' Y FACTOR=',F9.6//' INITIAL RUNOFF VALUE=',F9.3,
     2 3X,'LAG=',I3,' HOURS')
 6500 FORMAT(/5X,'AREA IN EACH ELEVATION ZONE'//
     1 ' ZONE',5X,'AREA',1X,'(',3A4,')')
 6900 FORMAT(/5X,'HYPSOMETRIC MEAN ELEVATION IN EACH ZONE',
     1  1X,'(',A8,')'//)
 7000 FORMAT(1X,I4,7X,E10.4)
 7600 FORMAT(/5X,'BASE STATION ELEVATION',
     1  1X,'(',A8,')'//)
 7700 FORMAT(5X,E10.4)
      END
      SUBROUTINE LAPSE(STATN,ND,NZ,MAXMIN,TEMPT,TMAX,TMIN,
     1 DTLR,UFLAG,MTHD,ZMEAN,IEXT,IDEGDY,T)
C
C***********************************************************************
C
C       FUNCTION - LAPSE IS A MODULAR TEMPERATURE PREPROCESSING ROUTINE
C                  FOR INPUT TEMPERATURES EXPRESSED AS MAX-MIN OR
C                  TEMPERATURES NOT ALREADY IN DEGREE-DAYS OR EX-
C                  TRAPOLATED TO EACH ELEVATION ZONE. ROUTINE LAPSE
C                  TAKES MAX-MIN DAILY TEMPERATURES IN DEGREES FROM THE
C                  BASE STATION AND EXTRAPOLATES THE TEMPERATURE TO
C                  THE ZONE AND COMPUTES THE TEMPERATURE IN DEGREE-DAYS.
C                  DEGREE-DAYS CAN BE COMPUTED BY ONE OF TWO METHODS:
C                   MEAN OR EFFECTIVE MINIMUM. TEMPERATURES NOT IN
C                   DEGREE-DAYS OR INPUT PER ZONE CAN BE COMPUTED IN
C                   DEGREE-DAYS OR EXTRAPOLATED TO EACH ELEVATION
C                   ZONE IF LAPSE RATES ARE PROVIDED.
C
C       ARGUMENT LIST
C       VARIABLE    TYPE   IO   DESCRIPTION
C       --------    ----   --   -----------
C       STATN       R*8    I    ELEVATION OF RECORDING STATION
C       ND          I*4    I    NUMBER OF SNOWMELT DAYS
C       NZ          I*4    I    NUMBER OF ZONES
C       MAXMIN      I*4    I    FLAG TO INDICATE IF TEMPS ARE MAX-MIN
C       TMAX        R*4    I    MAXIMUM TEMPERATURES IN DEGREES
C       TMIN        R*4    I    MINIMUM TEMPERATURES IN DEGREES
C       UFLAG       I*2    I    UNITS FLAG(ENGLISH OR METRIC)
C       MTHD        I*2    I    METHOD OF COMPUTING DEGREE DAYS
C                                (EFFECTIVE MINIMUM OR MEAN)
C       ZMEAN       R*8    I    HYPSOMETRIC MEAN ELEVATION OF EACH ZONE
C       IEXT        I*2    I    FLAG TO EXTRAPOLATE TO ELEVATION ZONES
C       IDEGDY      I*2    I    FLAG TO COMPUTE DEGREE-DAYS
C       TEMPT       R*4     O   COMPUTED TEMPERATURE IN DEGREE DAYS
C       T           R*4    I    TEMPERATURES IN DEGREES TO BE PROCESSED
C
C       EXTERNAL REFERENCES -- NONE.
C
C       CALLED BY -- MAIN (DRVSNO)
C
C       COMPUTER/LANGUAGE - IBM 360/91 AT GSFC/FORTRAN IV
C
C       DESIGNER/PROGRAMMER - G.MAJOR,RESEARCH & DATA SYSTEMS,INC.
C
C***********************************************************************
C
```

```
C
      DIMENSION ZCONST(8),TMAX(366),TMIN(366),ZMEAN(8),
     1 T(366,8),DTLR(366,8),TEMPT(366,8)
C
      REAL*8 ZMEAN,STATN,ZCONST
      INTEGER*2 MAXMIN,MTHD,UFLAG,IEXT,IDEGDY
C
C
      IF(UFLAG.EQ.0) TU=0.
      IF(UFLAG.EQ.1) TU=32.
C
C
C      CHECK IF TEMPERATURE IS TO BE COMPUTED IN DEGREE-DAYS
C
      IF(IDEGDY.EQ.0) GO TO 590
C
C      CHECK IF TEMPERATURES ARE MAX-MIN
C
      IF(MAXMIN.EQ.0) GO TO 52
C
C      CHECK METHOD OF COMPUTING DEGREE DAYS
C
      DO 600 I=1,ND
        IF(MTHD.EQ.1) GO TO 22
        IF(MTHD.EQ.0) GO TO 23
   22   IF(UFLAG.EQ.0.AND.TMIN(I).LT.0.) TMIN(I)=0.0
        IF(UFLAG.EQ.1.AND.TMIN(I).LT.32.) TMIN(I)=32.0
C
C      COMPUTE TEMPERATURE IN DEGREE DAYS
C
  23    T(I,1)=((TMAX(I)+TMIN(I))/2.)-TU
  600 CONTINUE
C
        GO TO 590
   52  CONTINUE
       DO 605 I=1,ND
         IF(MTHD.EQ.1) GO TO 53
         IF(MTHD.EQ.0) GO TO 54
   53    IF(UFLAG.EQ.0.AND.T(I,1).LT.0.) T(I,1)=0.
         IF(UFLAG.EQ.1.AND.T(I,1).LT.32.) T(I,1)=32.
  54     T(I,1)=T(I,1)-TU
  605  CONTINUE
  590 CONTINUE
C
C      CHECK IF TEMPERATURE IS TO BE AUTOMATICALLY EXTRAPOLATED TO
C      ELEVATION ZONE. IF NOT, USE THE LAPSE RATES GIVEN AS INPUT
C
      IF(IEXT.EQ.0) GO TO 950
      IF(UFLAG.EQ.0) ZCON=100.
      IF(UFLAG.EQ.1) ZCON=1000.
      DO 602 J=1,NZ
        ZCONST(J)=STATN-ZMEAN(J)
        DO 601 I=1,ND
          TEMPT(I,J)=T(I,1)+(ZCONST(J)/ZCON)*DTLR(1,1)
  601   CONTINUE
  602 CONTINUE
      GO TO 990
  950 CONTINUE
C
C      EXTRAPOLATE TEMPERATURES USING THE GIVEN LAPSE RATES
C
      DO 603 J=1,NZ
        DO 604 I=1,ND
          TEMPT(I,J)=T(1,1)+DTLR(I,J)
  604   CONTINUE
  603 CONTINUE
C
  990  DO 700 I=1,ND
         DO 701 J=1,NZ
           IF(TEMPT(I,J).LE.0.) TEMPT(I,J)=0.0
  701    CONTINUE
  700  CONTINUE
       RETURN
      END
C
      SUBROUTINE PRESNO
C
C*******************************************************************
C
C     FUNCTION - PRESNO COMPUTES THE PRECIPITATION CONTRIBUTING
C                TO RUNOFF IN EACH ELEVATION ZONE
C                FROM NON-SNOW COVERED AREAS OR FROM THE TOTAL
C                ZONE AREA. THE ALGORITHM FOR COMPUTING PRECIP
C                FROM NON-SNOW COVERED AREAS WAS DEVELOPED BY
C                RESOURCE CONSULTANTS,INC.
C
C     COMMON BLOCK VARIABLES USED-
C     VARIABLE  COMMON  TYPE  IO
C     --------  ------  ----  --
C     T         CLIDAT  R*4   I
```

```
C         S           CLIDAT   R*4     I
C         PRECIP      CLIDAT   R*4     I
C         AN          BASDAT   R*4     I
C         P           OUTDAT   R*4      O
C         UFLAG       OPTDAT   I*2     I
C         IPR         BASDAT   I*2     I
C
C         EXTERNAL REFERENCES - NONE
C
C         CALLED BY - MAIN
C
C         COMPUTER/LANGUAGE -- IBM 360/91 AT GSFC/FORTRAN IV
C
C         DESIGNER/PROGRAMMER -- G.MAJOR, RESEARCH & DATA SYSTEMS,INC.
C
C*************************************************************************
C
C
        DIMENSION RUNOF(366,8),TMAX(366),TMIN(366)
        REAL*8 BASIN,AREA,X,Y,SNOW,R,TZ,EP
        INTEGER*2 IRUN,MODE,IPRRUN,IPLT,IPRINT,UFLAG,ACTFLG,IZONE,
     1  IDTFLG,MTHD,ITPROC,IPR
C
C
C
C****** COMMON BLOCKS ******
C
        COMMON/CLIDAT/T(366,8),S(366,8),PRECIP(366,8),ACTUAL(366),
     1  TCRIT(366),ND
C
        COMMON/OUTDAT/P(366,8),QNP1X(367),X1(367),TEMPT(366,8)
C
        COMMON/OPTDAT/ISTMTH,IENMTH,IRUN,MODE,IPRRUN,IPLT,IPRINT,UFLAG,
     1  ACTFLG,IZONE(3),IDTFLG,MTHD,ITPROC
C
        COMMON/BASDAT/BASIN(2),AREA(8),X,Y,DTLR(366,8),AN(366,8),
     1 CS(366,8),CR(366),NZ,IYEAR,IPR(366,8)
C
C
C         ZERO OUT PRECIPITATION ARRAY FOR EACH RUN
C
        DO 15 J=1,ND
          DO 16 I=1,NZ
            P(J,I)=0.0
   16     CONTINUE
   15   CONTINUE
C
        DO 80 J=1,NZ
C
C          CHECK IF PRECIP INPUT IS BY ZONE
C
           IF(IZONE(2).EQ.0) NPZ=1
           IF(IZONE(2).EQ.1) NPZ=J
C
C         INITIALIZE ACCUMULATED SNOW TO 0
C
           SNOW=0.D0
C
C         INITIALIZE NON-SNOW COVERED (SNOWO) AND TOTAL SCA (SNOW1)
C         TO 0
C
           DO 90 I=1,ND
             SNOWO=0.0
             SNOW1=0.0
             IF(ITPROC.EQ.0) TZ=T(I,J)
             IF(ITPROC.EQ.1) TZ=TEMPT(I,J)
C
C            CHECK WHICH PRECIP METHOD TO USE; IPR=0 IS FOR
C            NON-SNOW COVERED AREAS AND IPR=1 IS FOR TOTAL AREA
C
             IF(IPR(I,J).EQ.0) SNOWO=S(I,J)
             IF(IPR(I,J).EQ.1) SNOW1=S(I,J)
C
C         COMPUTE RUNOFF FACTOR
C
             R=TZ*AN(I,J)
C
C         CHECK IF ANY PRECIPITATION IN ZONE
C         IF NO PRECIPITATION THEN CHECK SNOW TO BE MELTED
C
             IF(ABS(PRECIP(I,NPZ)).LT.0.00001) GO TO 12
C
C         CHECK FOR SNOWFALL IN ZONE
C         IF TEMPERATURE IS LESS THAN INPUT CRITICAL TEMPERATURE
C         THEN TREAT PRECIPITATION AS SNOWFALL
C
               IF(TZ.GT.TCRIT(I)) GO TO 11
C
C         ACCUMULATE SNOWFALL IN ZONE TO BE MELTED LATER
C
             SNOW=SNOW+PRECIP(I,NPZ)
```

```
C
C       SET COMPUTED PRECIP TO 0 AND CALCULATE PRECIP FOR
C       RUNOFF FROM NON-SCA
C
           P(I,J)=0.0
           GO TO 90
C
C       ASSIGN INPUT PRECIP TO COMPUTED PRECIP
C
  11       P(I,J)=PRECIP(1,NPZ)
C
C
C       CHECK PRECIPITATION IN ZONE TO BE MELTED
C
  12       IF(DABS(SNOW).LT.0.00001D0) GO TO 90
C
C       CHECK TEMPERATURE IN ZONE,CALCULATE RUNOFF FROM PRECIP
C       HELD AND COMPUTE AMOUNT OF SNOW TO BE MELTED
C
           IF(TZ.LT.0.D0) GO TO 90
           EP=R*(1.-SNOW1)
           IF(R.GT.SNOW) GO TO 13
           P(I,J)=P(I,J)+EP
C
C       SET ACCUMULATED SNOW TO SNOW MINUS RUNOFF
C
           SNOW=SNOW-R
           GO TO 90
C
C       CALCULATE EXTRA RUNOFF FROM PRECIP HELD
C       COMPUTE PRECIPITATION FROM SNOW ACCUMULATED AND TOTAL SCA
C       AND RESET ACCUMULATED SNOW TO 0
C
  13       P(I,J)=P(I,J)+(SNOW*(1.-SNOW1))
           SNOW=0.0
C
C       COMPUTE PRECIPITATION FROM AMOUNT OF SNOW COVER
C
 90     P(I,J)=P(I,J)*(1.-SNOWO)
  80   CONTINUE
C
 999   RETURN
       END
       SUBROUTINE RUNOFF
C
C***************************************************************************
C
C       FUNCTION - THIS ROUTINE COMPUTES THE PREDICTED STREAM RUNOFF
C                  BASED ON THE SNOWMELT-RUNOFF MODEL EQUATIONS BY
C                  RANGO AND MARTINEC. RUNOFF CAN BE COMPUTED IN FORCAST
C                  MODE BY UPDATING WITH ACTUAL DATA EVERY 7TH DAY.
C
C
C       COMMON BLOCK VARIABLES USED
C       VARIABLE   COMMON   TYPE  IO
C       --------   ------   ----  --
C       T          CLIDAT   R*4   I
C       S          CLIDAT   R*4   I
C       P          OUTDAT   R*4   I
C       QNP1X      OUTDAT   R*4    O
C       DTLR       BASDAT   R*4   I
C       AN         BASDAT   R*4   I
C       X1         OUTDAT   R*4    O
C       AREA       BASDAT   R*8   I
C       X          BASDAT   R*8   I
C       Y          BASDAT   R*8   I
C       ND         CLIDAT   I*4   I
C       NZ         BASDAT   I*4   I
C       CS         BASDAT   R*4   I
C       CR         BASDAT   R*4   I
C       UFLAG      OPTDAT   I*2   I
C       ACTUAL     CLIDAT   R*4   I
C       IZONE      OPTDAT   I*2   I
C       MODE       OPTDAT   I*4   I
C       PDR        GAGE     R*4   I
C       PDM2       GAGE     R*4   I
C       QNS        GAGE     R*8   I
C
C
C
C       EXTERNAL REFERENCES --
C           IOUT   - UTILITY ROUTINE TO OUTPUT RESULTS IN MONTHLY AND
C                    DAILY FORMAT.
C
C
C       CALLED BY -- MAIN
C
C       COMPUTER/LANGUAGE-- IBM 360/91 AT GSFC/FORTRAN IV
C
C       DESIGNER/PROGRAMMER -- G.MAJOR, RESEARCH & DATA SYSTEMS,INC.
```

```
C
C************************************************************************
      DIMENSION Z(8),RUNOF(366,8)
C
      REAL*8 ARG,QNS,ASUM,COV,PRUNOF(367),BASIN,AREA,X,Y,SUMRO
      INTEGER*2 IRUN,MODE,IPRRUN,IPLT,IPRINT,UFLAG,ACTFLG,IZONE,
     1  IDTFLG,MTHD,ITPROC,IPR,IOFLG,ROFLG,COFLG,DTFLG,TOFLG
      INTEGER*2 PUFLG
C
C
C****COMMON BLOCKS****
C
      COMMON/CLIDAT/T(366,8),S(366,8),PRECIP(366,8),ACTUAL(366),
     1  TCRIT(366),ND
C
      COMMON/OUTDAT/P(366,8),QNP1X(367),X1(367),TEMPT(366,8)
C
      COMMON/OPTDAT/ISTMTH,IENMTH,IRUN,MODE,IPRRUN,IPLT,IPRINT,UFLAG,
     1  ACTFLG,IZONE(3),IDTFLG,MTHD,ITPROC
C
      COMMON/BASDAT/BASIN(2),AREA(8),X,Y,DTLR(366,8),AN(366,8),
     1 CS(366,8),CR(366),NZ,IYEAR,IPR(366,8)
C
      COMMON/GAGE/QNS,PDR(367),PDM2(367)
C
C
C       ZERO OUT RUNOFF ARRAY FOR EACH RUN
C
      DO 10 I1=1,367
        QNP1X(I1)=0.0
        X1(I1)=0.0
        PRUNOF(I1)=0.D0
   10 CONTINUE
C
C       INITIALIZE RUNOFF AND CHECK UNITS FLAG
C
      IF(UFLAG.EQ.0) COV=0.01D0/86400.D0
      IF(UFLAG.EQ.1) COV=0.0833D0/86400.D0
C
C
C       COMBINE SNOW COVER AND PRECIPITATION DATA AND ACCUMULATE
C       FOR EACH ZONE.
C
      NDAY=0
C
C       CHECK FORCAST MODE
C
      IF(MODE.EQ.1) NDAY=7
      DO 3 I=1,ND
        ASUM=0.D0
        DO 2 J=1,NZ
C
C            CHECK IF TEMPERATURE AND RUNOFF COEFFICIENTS ARE INPUT
C            BY ZONES.
C
          IF(IZONE(3).EQ.0) NCZ=1
          IF(IZONE(3).EQ.1) NCZ=J
C
          IF(ITPROC.EQ.0) Z(J)=T(I,J)
          IF(ITPROC.EQ.1) Z(J)=TEMPT(I,J)
          IF(Z(J).LT.0.D0) Z(J)=0.D0
C
C       COMPUTE SNOWMELT DEPTH IN EACH ZONE
C
      RUNOF(I,J)=AN(I,J)*Z(J)*S(I,J)+P(I,J)
C
C       CHECK RUNOFF COEFFICIENTS FOR RAIN OR SNOW (CR OR CS)
C
      IF(CR(I).EQ.0.0) CR1=CS(I,NCZ)
      IF(CR(I).GT.0.0) CR1=CR(I)
C
C       COMPUTE SNOWMELT RUNOFF
C
      SUMRO=(CS(I,NCZ)*AN(I,J)*Z(J)*S(I,J)+CR1*P(I,J))*(AREA(J)*COV)
          ASUM=ASUM+SUMRO
    2   CONTINUE
C
C       COMPUTE RECESSION COEFFICIENT FOR BASIN
C
        ARG=1.D0-(X*QNS**Y)
      IF(I.EQ.1) PRUNOF(I)=QNS
C
C       CHECK FOR STREAMFLOW LAG
C       CHECK IF STREAMFLOW LAG IS FROM PREVIOUS(DAY N-1) RUNOFF
C       OR FROM DAY N-2 RUNOFF
C
      IF(PDR(I).EQ.0.) PRUNOF(I)=PDM2(I)*PRUNOF(I-1)+(1.-PDM2(I))*
     1 PRUNOF(I)
C
      IF(PDR(I).EQ.0.) PDR1=1.0
```

```
      IF(PDR(I).GT.0.) PDR1=PDR(I)
C
C
C      COMPUTE STREAMFLOW
C
      QNP1X(I)=(PDR1*PRUNOF(I)+(1.-PDR1)*ASUM)*ARG+(X*QNS**(1.D0+Y))
      PRUNOF(I+1)=ASUM
C
C      IF IN FORECAST MODE SUBSTITUTE THE RUNOFF VALUE FOR THE
C      NEXT DAY WITH THE ACTUAL RUNOFF VALUE EVERY SEVENTH DAY
C
      IF(NDAY.EQ.I) GO TO 850
      QNS=QNP1X(I)
      GO TO 900
  850  IF(NDAY.GT.ND) NDAY=ND
      QNS=ACTUAL(NDAY)
      NDAY=NDAY+7
 900  CONTINUE
C
      X1(I)=I
   3  CONTINUE
C
      X1(ND+1)=X1(ND)+1.
C
C      WRITE PREDICTED STREAMFLOW FOR EACH ZONE
C
      IF(IPRRUN.EQ.0) GO TO 100
C
      IOFLG=0
      ROFLG=0
      COFLG=0
      DTFLG=0
      TOFLG=0
      POFLG=1
      CALL IOUT(NZ,BASIN,IYEAR,IZONE,ISTMTH,IENMTH,T,PRECIP,S,IPK,
     1 RUNOF,QNP1X,ACTUAL,CS,AN,DTLR,UFLAG,IOFLG,ROFLG,COFLG,DTFLG,
     2 TMAX,TMIN,TCRIT,CR,P,TOFLG,POFLG)
 100   CONTINUE
C
C      WRITE COMPUTED AND ACTUAL SNOWMELT RUNOFF
C
C
      IOFLG=0
      ROFLG=1
      COFLG=0
      PRTFLG=0
      TOFLG=0
      POFLG=0
      CALL IOUT(NZ,BASIN,IYEAR,IZONE,ISTMTH,IENMTH,T,PRECIP,S,IPK,
     1 RUNOF,QNP1X,ACTUAL,CS,AN,DTLR,UFLAG,IOFLG,ROFLG,COFLG,PRTFLG,
     2 TMAX,TMIN,TCRIT,CR,P,TOFLG,POFLG)
C
C
C
 999  RETURN
      END
C
C
C
C
      SUBROUTINE GOOD(QNP1X,ACTUAL,ND)
C
C***********************************************************************
C
C     FUNCTION - GOOD COMPUTES THE NASH-SUTCLIFFE GOODNESS OF FIT
C                MEASURE AND CALCULATES THE TOTAL SIMULATED AND
C                ACTUAL VOLUME AND THE PER CENT SEASONAL DIFFERENCE
C                BETWEEN THE ACTUAL AND SIMULATED STREAM RUNOFF.
C
C
C     ARGUMENT LIST -
C     VARIABLE   TYPE  IO  DESCRIPTION
C     --------   ----  --  -----------
C     QNP1X      R*4   I   ARRAY OF SIMULATED STREAM RUNOFF DATA
C     ACTUAL     R*4   I   ARRAY OF ACTUAL STREAM RUNOFF DATA
C     ND         I*4   I   NUMBER OF SNOWMELT DAYS
C
C     OUTPUTS:
C        XNSR2  -  NASH-SUTCLIFFE GOODNESS OF FIT MEASURE
C        VOL    -  TOTAL VOLUME OF COMPUTED STREAM RUNOFF
C        ASUM   -  TOTAL VOLUME OF ACTUAL STREAM RUNOFF
C        PCT    -  PER CENT SEASONAL DIFFERENCE BETWEEN ACTUAL
C                  AND SIMULATED STREAM RUNOFF
C        AMEAN  -  MEAN ACTUAL STREAM RUNOFF
C        QMEAN  -  MEAN COMPUTED STREAM RUNOFF
C
C
C
C     EXTERNAL REFERENCES -- NONE.
C
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C        CALLED BY -- MAIN.
C
C        COMPUTER/LANGUAGE - IBM 360/91 AT GSFC/FORTRAN IV
C
C        DESIGNER/PROGRAMMER -- G.MAJOR, RESEARCH & DATA SYSTEMS,INC.
C
C***********************************************************************
C
        DIMENSION QNP1X(367),ACTUAL(366)
C
C
C        COMPUTE MEAN AND TOTAL ACTUAL STREAMFLOW
C
        ASUM=0.0
        DO 10 I=1,ND
          ASUM=ASUM+ACTUAL(I)
   10   CONTINUE
        DAYS=ND
        AMEAN=ASUM/DAYS
        WRITE(6,5000) ASUM,AMEAN
C
C        CALCULATE TOTAL VOLUME
C
        VOL=0.0
        DO 50 I=1,ND
          VOL=VOL+QNP1X(I)
   50   CONTINUE
C
        QMEAN=VOL/DAYS
        WRITE(6,6000) VOL,QMEAN
C
C        CALCULATE NASH-SUTCLIFFE GOODNESS OF FIT MEASURE
C
        E=0.0
        F=0.0
        ONEN=1./DAYS
        DO 30 I=1,ND
          E=E+(ACTUAL(I)-AMEAN)**2
          F=F+(ACTUAL(I)-QNP1X(I))**2
    30  CONTINUE
        XNSR2=(ONEN*E-ONEN*F)/(ONEN*E)
C
        WRITE(6,5500) XNSR2
C
C        COMPUTE SEASONAL DIFFERENCE
C
        PCT=((ASUM-VOL)/ASUM)*100.
C
        WRITE(6,6500) PCT
C
  6000  FORMAT(/' TOTAL COMPUTED VOLUME=  ',F15.4,/
     1   ' MEAN COMPUTED VOLUME=    ',F15.4//)
  5500   FORMAT(/' GOODNESS OF FIT MEASURE=',F15.4//)
  5000   FORMAT(//' TOTAL ACTUAL STREAMFLOW=',F15.4,/
     1 ' MEAN ACTUAL STREAMFLOW= ',F15.4//)
  6500   FORMAT(//' PERCENT SEASONAL DIFFERENCE=',F15.4//)
        RETURN
        END
        SUBROUTINE IOUT(NZ,BASIN,IYEAR,IZONE,ISTMTH,IENMTH,T,PRECIP,S,
     1 IPR,RUNOF,QNP1X,ACTUAL,CS,AN,DTLR,UFLAG,IOFLG,ROFLG,COFLG,
     2  DTFLG,TMAX,TMIN,TCRIT,CR,P,TOFLG,POFLG)
C
C=================================================================
C
C        FUNCTION - IOUT IS A UTILITY ROUTINE TO PRINT OUT MONTHLY
C                   AND DAILY VALUES IN TABULAR FORM FOR VARIOUS
C                   SNOWMELT RUNOFF MODEL PARAMETERS.
C
C
C        ARGUMENT LIST --
C        VARIABLE  TYPE  IO  DESCRIPTION
C        --------  ----  --  -----------
C        NZ        I*4   IO  NUMBER OF ZONES IN BASIN
C        BASIN     R*8   IO  BASIN NAME
C        IYEAR     I*4   IO  MODEL YEAR
C        IZONE     I*2   I   FLAG FOR CHECKING IF INPUT IS BY ZONE
C        ISTMTH    I*4   I   START MONTH
C        IENMTH    I*4   I   END MONTH
C        T         R*4   IO  TEMPERATURE DATA
C        PRECIP    R*4   IO  PRECIPITATION DATA
C        S         R*4   IO  SNOW COVERED AREA
C        IPR       I*4   IO  PRECIPITATION METHOD
C        RUNOF     R*4   IO  DEPTH BY ZONE
C        QNP1X     R*4   IO  DAILY STREAM RUNOFF
C        ACTUAL    R*4   IO  ACTUAL STREAM RUNOFF
C        CS        R*4   IO  RUNOFF COEFFICIENTS FOR SNOW
C        AN        R*4   IO  DEGREE DAY FACTORS
C        DTLR      R*4   IO  TEMPERATURE LAPSE RATE CORRECTION
C        TMAX      R*4   IO  MAXIMUM TEMPERATURES
C        TMIN      R*4   IO  MINIMUM TEMPERATURES
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C        TCRIT      R*4    IO  CRITICAL TEMPERATURE
C        CR         R*4    IO  RUNOFF COEFFICIENTS FOR RAIN
C        P          R*4    IO  PRECIPITAION CONTRIBUTING TO RUNOFF
C        UFLAG      I*2    I   UNITS FLAG
C        IOFLG      I*2    I   FLAG IF TEMPERATURE,PRECIPITATION AND SNOW
C                              COVERED AREA IS TO BE OUTPUT
C        ROFLG      I*2    I   FLAG IF DAILY AND ACTUAL STREAM RUNOFF IS TO
C                              OUTPUT
C        COFLG      I*2    I   FLAG IF RUNOFF COEFFICIENTS,DEGREE DAY
C                              FACTORS AND PRECIPITATION METHOD INDEX
C                              ARE TO BE OUTPUT
C        DTFLG      I*2    I   FLAG IF LAPSE RATE AND CRITICAL
C                              TEMPERATURE IS TO BE OUTPUT
C        TOFLG      I*2    I   FLAG IF MAX-MIN,CRTITCAL TEMPS ARE TO
C                              BE OUTPUT
C        POFLG      I*2    I   FLAG IF DEPTH BY ZONE AND COMPUTED
C                              PRECIPITATION CONTIBUTING TO RUNOFF
C                              ARE TO BE OUTPUT
C
C      EXTERNAL REFERENCES - NONE.
C
C      CALLED FROM:
C          SNODRV
C          READIN
C          RUNOFF
C          PRESNO
C
C      LANGUAGE/COMPUTER - FORTRAN IV/IBM 360/91 AT GSFC
C
C      PROGRAMMER/DESIGNER - G. MAJOR, RESEARCH & DATA SYSTEMS,INC.
C
C
C=====================================================================
C
      REAL*8 BASIN(2),CMP,ACT,TX,TN
      INTEGER*2 IZONE(3),UFLAG,IOFLG,ROFLG,COFLG,DTFLG,IPR(366,8),
     1          TOFLG,POFLG
C
      DIMENSION NDAYS(24),MO(24),ARENAM(8),AO(12),BO(12),CO(12),
     1 T(366,8),PRECIP(366,8),S(366,8),RUNOF(366,8),QNP1X(367),
     2 ACTUAL(366),CS(366,8),AN(366,8),DTLR(366,8),IDO(12),DP(12)
      DIMENSION C1(12),AA(12),DT(12),PRE(12),T1(12),P1(12),SN(12)
      DIMENSION CMP(12),ACT(12),TX(12),TN(12),TC(12),CR1(12),P2(12)
      DIMENSION P(366,8),TMAX(366),TMIN(366),TCRIT(366),CR(366)
C
      DATA NDAYS/31,29,31,30,31,30,31,31,30,31,30,31,12*0/
      DATA ARENAM/'A','B','C','D','E','F','G','H'/
      DATA MO(1)/4HJAN /
      DATA MO(2)/4HFEB /
      DATA MO(3)/4HMAR /
      DATA MO(4)/4HAPR /
      DATA MO(5)/4HMAY /
      DATA MO(6)/4HJUN /
      DATA MO(7)/4HJUL /
      DATA MO(8)/4HAUG /
      DATA MO(9)/4HSEP /
      DATA MO(10)/4HOCT /
      DATA MO(11)/4HNOV /
      DATA MO(12)/4HDEC /
      DATA C1/12*'CS  '/
      DATA AA/12*'AN  '/
      DATA TX/12*'MAX TEMP'/
      DATA TN/12*'MIN TEMP'/
      DATA TC/12*'TCR1'/
      DATA CR1/12*'CR  '/
      DATA DT/12*'DTLR'/
      DATA PRE/12*'PR  '/
      DATA T1/12*'DD  '/
      DATA P1/12*'PREC'/
      DATA SN/12*'SCA '/
      DATA CMP/12*'COMPUTED'/
      DATA ACT/12*'ACTUAL  '/
      DATA P2/12*'CPRE'/
      DATA DP/12*'DPTH'/
C
      DO 60 I=1,12
        J=I+12
        MO(J)=MO(I)
        NDAYS(J)=NDAYS(I)
        AO(I)=0.0
        BO(I)=0.0
        CO(I)=0.0
   60 CONTINUE
C
C     COMPUTE NUMBER OF MONTHS AND CHECK IF GREATER THAN 6
C
      IDATZ=0
      NMONTH=(IENMTH-ISTMTH)+1
      NM1=NMONTH
      IF(NMONTH.GT.6) GO TO 20
```

```
      GO TO 30
   20 IDATZ=1
      IEND=ISTMTH+5
   30 CONTINUE
C
C      CHECK IF MORE THAN 1 YEAR IS BEING MODELLED
C
      IF(IENMTH.LE.12) IY=IYEAR
      IF(IENMTH.GT.12) IY=IYEAR+1
C
C     LOOP OVER NUMBER OF ZONES
C
      DO 50 J=1,NZ
         IFLAG=0
         IF(IDATZ.EQ.0) IEND=IENMTH
         WRITE(6,9999)
C
C      CHECK IF POFLG FOR COMPUTED PRECIP OUTPUT
C
      IF(POFLG.EQ.0) GO TO 105
      WRITE(6,1201)
      WRITE(6,1000) BASIN,IYEAR,ARENAM(J),(MO(M1),M1=ISTMTH,IEND)
      IF(NMONTH.GT.6) NM1=6
      WRITE(6,1009) (DP(IN),P2(IN),IN=1,NM1)
      GO TO 300
  105 CONTINUE
C
C    CHECK COFLG FOR OUTPUT PARAMETERS
C
         IF(COFLG.EQ.0) GO TO 100
         J1=J
C
C     CHECK IF INPUT IS BY ZONE AND WRITE OUT HEADER INFORMATION FOR
C     RUNOFF COEFFICIENTS(CS),DEGREE DAY FACTORS(AN) AND TEMPERATURE
C     LAPSE RATES(DTLR)
C
         IF(IZONE(3).EQ.0) J1=1
         WRITE(6,1001)
          WRITE(6,1000) BASIN,IYEAR,ARENAM(J),(MO(M1),M1=ISTMTH,IEND)
           IF(NMONTH.GT.6) NM1=6
           WRITE(6,1010) (AA(IN),C1(IN),CR1(IN),PRE(IN),IN=1,NM1)
          GO TO 300
  100     CONTINUE
C
C      CHECK DTFLG FOR OUTPUT PARAMETERS
C
           IF(DTFLG.EQ.0) GO TO 101
           WRITE(6,2001)
          WRITE(6,1000) BASIN,IYEAR,ARENAM(J),(MO(M1),M1=ISTMTH,IEND)
           IF(NMONTH.GT.6) NM1=6
           WRITE(6,1011) (DT(IN),TC(IN),IN=1,NM1)
           GO TO 300
  101      CONTINUE
C
C     CHECK IOFLG FOR OUTPUT PARAMETERS
C
          IF(IOFLG.EQ.0) GO TO 110
          J2=J
C
C     CHECK IF INPUT BY ZONE
C
         IF(IZONE(2).EQ.0) J2=1
C
C     WRITE HEADER INFORMATION FOR TEMPERATURE(T),PRECIPITATION
C     (PRECIP),AND SNOW COVERED AREA(S).
C
          WRITE(6,1501)
         WRITE(6,1000) BASIN,IYEAR,ARENAM(J),(MO(M1),M1=ISTMTH,IEND)
         IF(NMONTH.GT.6) NM1=6
          WRITE(6,1510) (T1(IN),P1(IN),SN(IN),IN=1,NM1)
         GO TO 300
  110    CONTINUE
C
C     CHECK  ROFLG FOR OUTPUT PARMATERS
C
         IF(ROFLG.EQ.1) GO TO 130
         IF(TOFLG.EQ.1) GO TO 131
         GO TO 300
C
C     WRITE HEADER INFORMATION FOR SIMULATED RUNOFF (QNP1X) AND ACTUAL
C     (ACTUAL) DATA
C
  130    WRITE(6,2002)
         WRITE(6,3000) BASIN,IYEAR,(MO(M1),M1=ISTMTH,IEND)
         IF(NMONTH.GT.6) NM1=6
          WRITE(6,3010) (CMP(IN),ACT(IN),IN=1,NM1)
          GO TO 300
C
C      CHECK TOFLG AND OUTPUT MAX-MIN HEADER INFORMATION
C
```

```
 131      WRITE(6,3001)
          WRITE(6,3000) BASIN,IYEAR,(MO(M1),M1=ISTMTH,IEND)
          IF(NMONTH.GT.6) NM1=6
          WRITE(6,3020) (TX(IN),TN(IN),IN=1,NM1)
  300       CONTINUE
C
C       CHECK FLAGS FOR WRITING DATA IF OVER 6 MONTHS DATA AVAILABLE
C
C
C       LOOP FOR NUMBER OF DAYS IN MONTH
C
    5     DO 10 ID=1,31
            IWICH=ID
            IS=ISTMTH
            DO 15 IM=1,NMONTH
C
C
C        CHECK POFLG FOR OUTPUT DATA AND BLANK OUT DAYS WHERE
C        NO DATA IS AVAILABLE
C
        IF(POFLG.EQ.0) GO TO 155
        AO(IM)=RUNOF(IWICH,J)
        BO(IM)=P(IWICH,J)
                IF(MOD(IY,4).EQ.0) GO TO 81
                IF(IS.EQ.2.OR.IS.EQ.14.AND.ID.GE.29) GO TO 156
   81   IF(ID.GT.NDAYS(IS)) GO TO 156
        GO TO 180
  156   AO(IM)=999999.
        BO(IM)=999999.
        GO TO 180
 155    CONTINUE
C
C       CHECK COFLG FOR OUTPUT DATA AND BLANK OUT DAYS WHERE DATA IS
C       NOT AVAILABLE
C
              IF(COFLG.EQ.0) GO TO 160
                AO(IM)=AN(IWICH,J)
                BO(IM)=CS(IWICH,J1)
                CO(IM)=CR(IWICH)
                IDO(IM)=IPR(IWICH,J)
                IF(MOD(IY,4).EQ.0) GO TO 82
                IF(IS.EQ.2.OR.IS.EQ.14.AND.ID.GE.29) GO TO 151
  82            IF(ID.GT.NDAYS(IS)) GO TO 151
                GO TO 180
 151            AO(IM)=999999.
                BO(IM)=999999.
                CO(IM)=999999.
                IDO(IM)=999
                GO TO 180
  160         CONTINUE
C
C         CHECK DTFLG FOR OUPUT AND BLANK OUT DAYS WHERE NO DATA
C         IS AVAILABLE
             IF(DTFLG.EQ.0) GO TO 161
            AO(IM)=DTLR(IWICH,J)
             BO(IM)=TCRIT(IWICH)
              IF(MOD(IY,4).EQ.0) GO TO 162
              IF(IS.EQ.2.OR.IS.EQ.14.AND.ID.GE.29) GO TO 163
  162         IF(ID.GT.NDAYS(IS)) GO TO 163
              GO TO 180
 163         AO(IM)=999999.
              BO(IM)=999999.
              GO TO 180
  161         CONTINUE
C
C       CHECK IOFLG FOR OUTPUT DATA AND BLANK OUT DAYS WHERE NO DATA
C       IS AVAILABLE
C
              IF(IOFLG.EQ.0) GO TO 170
              AO(IM)=T(IWICH,J)
              BO(IM)=PRECIP(IWICH,J2)
              CO(IM)=S(IWICH,J)
                IF(MOD(IY,4).EQ.0) GO TO 83
                IF(IS.EQ.2.OR.IS.EQ.14.AND.ID.GE.29) GO TO 171
 83           IF(ID.GT.NDAYS(IS)) GO TO 171
              GO TO 180
  171         AO(IM)=999999.
              BO(IM)=999999.
              CO(IM)=999999.
             GO TO 180
 170       CONTINUE
C
C       CHECK ROFLG FOR OUTPUT DATA AND BLANK OUT DAYS WHERE DATA IS
C       NOT AVAILABLE
C
           IF(ROFLG.EQ.0) GO TO 182
             AO(IM)=QNP1X(IWICH)
             BO(IM)=ACTUAL(IWICH)
                IF(MOD(IY,4).EQ.0) GO TO 84
                IF(IS.EQ.2.OR.IS.EQ.14.AND.ID.GE.29) GO TO 181
```

```
 84        IF(ID.GT.NDAYS(IS)) GO TO 181
           GO TO 180
  181      AO(IM)=9999999.
           BO(IM)=9999999.
           GO TO 180
C
C      CHECK TOFLG FOR OUTPUT DATA AND BLANK OUT DAYS WHERE
C      NO DATA IS AVAILABLE
C
  182   IF(TOFLG.EQ.0) GO TO 180
        AO(IM)=TMAX(IWICH)
        BO(IM)=TMIN(IWICH)
              IF(MOD(IY,4).EQ.0) GO TO 85
              IF(IS.EQ.2.OR.IS.EQ.14.AND.ID.GE.29) GO TO 183
 85     IF(ID.GT.NDAYS(IS)) GO TO 183
        GO TO 180
 183    AO(IM)=999999.
        BO(IM)=999999.
  180    CONTINUE
C
      IF(MOD(IY,4).EQ.0) GO TO 70
      IF(IS.EQ.2.OR.IS.EQ.14) GO TO 71
      GO TO 70
  71  NDY=NDAYS(IS)-1
      GO TO 72
  70  NDY=NDAYS(IS)
C
 72         IWICH=IWICH+NDY
            IS=IS+1
  15      CONTINUE
C
           IF(IDATZ.EQ.0) KEND=NMONTH
           IF(IDATZ.EQ.1) KEND=6
C
C      CHECK POFLG AND OUTPUT DATA
C
      IF(POFLG.EQ.0) GO TO 199
      IF(IFLAG.EQ.0) WRITE(6,9009) ID,(AO(K),BO(K),K=1,KEND)
      IF(IFLAG.EQ.1) WRITE(6,9009) ID,(AO(K1),BO(K1),
     1  K1=7,NMONTH)
      GO TO 10
 199    CONTINUE
C
C
C     CHECK COFLG AND OUTPUT DATA
C
            IF(COFLG.EQ.0) GO TO 210
         IF(IFLAG.EQ.0) WRITE(6,5500) ID,(AO(K),BO(K),CO(K),IDO(K),
     1 K=1,KEND)
              IF(IFLAG.EQ.1) WRITE(6,5500) ID,(AO(K1),BO(K1),CO(K1),
     1        IDO(K1),K1=7,NMONTH)
C
              GO TO 10
 210        CONTINUE
C
C      CHECK DTFLG AND OUTPUT DATA
C
          IF(DTFLG.EQ.0) GO TO 221
          IF(IFLAG.EQ.0) WRITE(6,5011) ID,(AO(K),BO(K),K=1,KEND)
          IF(IFLAG.EQ.1) WRITE(6,5011) ID,(AO(K1),BO(K1),K1=7,NMONTH)
          GO TO 10
 221      CONTINUE
C
C     CHECK IOFLG AND OUTPUT DATA
C
            IF(IOFLG.EQ.0) GO TO 220
            IF(IFLAG.EQ.0) WRITE(6,6000) ID,(AO(K),BO(K),CO(K),
     1       K=1,KEND)
           IF(IFLAG.FQ.1) WRITE(6,6000) ID,(AO(K1),BO(K1),CO(K1),
     1  K1=7,NMONTH)
            GO TO 10
  220     CONTINUE
C
C     CHECK ROFLG AND OUTPUT DATA
C
          IF(ROFLG.EQ.0) GO TO 230
           IF(IFLAG.EQ.1) GO TO 40
          IF(UFLAG.EQ.1) WRITE(6,7000) ID,(AO(K),BO(K),K=1,KEND)
          IF(UFLAG.EQ.0) WRITE(6,7001) ID,(AO(K),BO(K),K=1,KEND)
 40       IF(IFLAG.EQ.0) GO TO 10
          IF(UFLAG.EQ.1) WRITE(6,7000) ID,(AO(K1),BO(K1),K1=7,NMONTH)
          IF(UFLAG.EQ.0) WRITE(6,7001) ID,(AO(K1),BO(K1),K1=7,NMONTH)
        GO TO 10
 230      CONTINUE
C
C      CHECK TOFLG AND OUTPUT DATA
C
           IF(TOFLG.EQ.0) GO TO 232
           IF(IFLAG.EQ.0) WRITE(6,9000) ID,(AO(K),BO(K),
     1     K=1,KEND)
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              IF(IFLAG.EQ.1) WRITE(6,9000) ID,(A0(K1),B0(K1),
     1        K1=7,NMONTH)
  232         CONTINUE
  10        CONTINUE
C
C         CHECK ALL FLAGS AGAIN AND OUTPUT DATA FOR OVER 6 MONTHS
C
            IF(IFLAG.EQ.1) GO TO 51
            IF(IDATZ.EQ.1) IFLAG=IFLAG+1
            IF(IDATZ.EQ.0) GO TO 51
            IENM2=IEND+1
          IF(POFLG.EQ.0) GO TO 399
           WRITE(6,1201)
          WRITE(6,1000) BASIN,IYEAR,ARENAM(J),(MO(M2),M2=IENM2,IENMTH)
          WRITE(6,1009) (DP(IN),P2(IN),IN=7,NMONTH)
          GO TO 5
 399       CONTINUE
              IF(COFLG.EQ.0) GO TO 400
              WRITE(6,1001)
              WRITE(6,1000) BASIN,IYEAR,ARENAM(J),(MO(M2),M2=IENM2,IENMTH)
               WRITE(6,1010) (AA(IN),C1(IN),CR1(IN),PRE(IN),IN=7,NMONTH)
              GO TO 5
 400          CONTINUE
              IF(DTFLG.EQ.0) GO TO 401
              WRITE(6,2001)
              WRITE(6,1000) BASIN,IYEAR,ARENAM(J),(MO(M2),M2=IENM2,IENMTH)
              WRITE(6,1011) (DT(IN),TC(IN),IN=7,NMONTH)
              GO TO 5
  401         CONTINUE
              IF(IOFLG.EQ.0) GO TO 410
              WRITE(6,1501)
              WRITE(6,1000) BASIN,IYEAR,ARENAM(J),(MO(M2),M2=IENM2,IENMTH)
              WRITE(6,1510) (T1(IN),P1(IN),SN(IN),IN=7,NMONTH)
              GO TO 5
 410          CONTINUE
              IF(ROFLG.EQ.0) GO TO 421
              WRITE(6,2002)
              WRITE(6,3000) BASIN,IYEAR,(MO(M2),M2=IENM2,IENMTH)
              WRITE(6,3010) (CMP(IN),ACT(IN),IN=7,NMONTH)
                GO TO 5
  421       CONTINUE
            IF(TOFLG.EQ.0) GO TO 51
            WRITE(6,3001)
            WRITE(6,3000) BASIN,IYEAR,(MO(M2),M2=IENM2,IENMTH)
            WRITE(6,3020) (TX(IN),TN(IN),IN=7,NMONTH)
            GO TO 5
C
 51         IF(COFLG.EQ.1) GO TO 50
            IF(ROFLG.EQ.1) GO TO 999
          IF(TOFLG.EQ.1) GO TO 999
  50      CONTINUE
 999      RETURN
C
C         FORMAT STATEMENTS:
C
 9999         FORMAT('C',///////)
 1000     FORMAT(//5X,'RANGO-MARTINEC MODEL FOR  ',2A8,2X,'YEAR=',I5//
     1 10X,'DATA FOR ZONE',A5//
     2 1X,'DAY ',6X,6(A4,16X)/)
 1010     FORMAT(6X,6(A4,2X,A4,1X,A4,2X,A4)/)
 1011      FORMAT(5X,6(2X,A4,4X,A4,6X)/)
 1510     FORMAT(6(4X,A4,1X,A4,3X,A4)/)
 3000     FORMAT(//5X,'RANGO-MARTINEC MODEL FOR  ',2A8,2X,'YEAR=',I5//
     1 1X,'DAY ',6X,6(A4,16X)/)
 3010     FORMAT(2X,6(1X,A8,3X,A8)/)
 3020     FORMAT(3X,6(1X,A8,1X,A8,2X)/)
 5000     FORMAT(1X,I2,2X,6(6X,F10.3))
 5011     FORMAT(1X,I2,2X,6(F6.2,4X,F4.2,6X))
 5500     FORMAT(1X,I2,3X,6(F4.2,2X,F4.2,1X,F4.2,3X,I1,2X))
 6000     FORMAT(1X,I2,1X,6(F6.2,1X,F5.2,1X,F5.3,2X))
 7000      FORMAT(1X,I2,1X,6(F6.0,4X,F6.0,4X))
 7001      FORMAT(1X,I2,1X,6(F7.3,2X,F7.3,4X))
 9000      FORMAT(1X,I2,2X,6(F6.2,3X,F6.2,5X))
 1009      FORMAT(5X,6(2X,A4,4X,A4,6X)/)
 9009       FORMAT(1X,I2,2X,6(1X,F5.3,3X,F5.3,6X))
 1201      FORMAT(/5X,'DAILY SNOW DEPTH BY ZONE IN CM.M**2(DPTH),
     1 DAILY COMPUTED PRECIP CONTRIBUTING TO RUNOFF(CPRE)'/)
 1001     FORMAT(/5X,'DEGREE-DAY FACTORS(AN),RUNOFF COEFFICIENTS FOR
     1  SNOW(CS), FOR RAIN(CR), PRECIP METHOD(PR)'/)
 1501     FORMAT(/5X,'DAILY TEMP IN DEGREE-DAYS(DD),INPUT PRECIP(PREC),
     1 SNOW COVERED AREA IN %(SCA)'/)
 2001      FORMAT(/5X,'LAPSE RATE(DTLR), CRITICAL TEMPERATURE(TCRT)'/)
 2002     FORMAT(/5X,'DAILY COMPUTED AND ACTUAL SNOWMELT RUNOFF DATA'/)
 3001     FORMAT(/5X,'DAILY MAXIMUM AND MINIMUM TEMPERATURES'/)
          END
          SUBROUTINE PLOTR(QNP1X,ACTUAL,X1,ND,UFLAG,ACTFLG)
C
C***********************************************************************
C
C          FUNCTION - PLOTR CALLS THE FORTRAN PRPLOT PRINTER-PLOT
```

```
C                  PACKAGE TO PLOT ACTUAL AND SIMULATED STREAM
C                  RUNOFF AS A FUNCTION OF STREAM DISCHARGE VS.
C                  NUMBER OF SNOWMELT DAYS.
C
C
C         ARGUMENT LIST -
C         VARIABLE  TYPE  IO  DESCRIPTION
C         --------  ----  --  -----------
C         QNP1X     R*4   IO  ARRAY OF SIMULATED STREAM RUNOFF DATA
C         ACTUAL    R*4   IO  ARRAY OF ACTUAL STREAM RUNOFF
C         X1        R*4   IO  ARRAY OF SNOWMELT DAYS
C         ND        I*4   I   NUMBER OF SNOWMELT DAYS
C         UFLAG     I*2   I   UNITS FLAG: 0=METRIC UNITS,1=ENGLISH UNITS
C         ACTFLG    I*2   I   ACTUAL DATA FLAG: 0=NO ACTUAL DATA
C                             AVAILABLE,1=ACTUAL DATA AVAILABLE
C
C
C
C         EXTERNAL REFERENCES --
C            PLOT1 - PRPLOT ROUTINE TO DETERMINE PLOT SCALE FACTORS AND
C                    DIMENSIONS OF LENGTH AND WIDTH OF PLOT IMAGE.
C            PLOT2 - PRPLOT ROUTINE CONSTRUCTS  GRID1 IMAGE IN CORE.
C            PLOT3 - PRPLOT ROUTINE PUTS SPECIFIED CHARACTER IN POSITION
C                    CORRESPONDING TO VALUE(S) OF X AND Y.
C            PLOT4 - PRPLOT ROUTINE WRITES IMAGE OF COMPLETED GRAPH ON
C                    UNIT FT06F001. PRINTS LABEL FOR ORDINATE ON LEFT
C                    EDGE OF PLOT.
C
C
C        CALLED BY -- MAIN
C
C         COMPUTER/LANGUAGE -- IBM 360/91 AT GSFC/FORTRAN IV
C
C         DESIGNER/PROGRAMMER -- G. MAJOR,RESEARCH & DATA SYSTEMS, INC.
C
C*************************************************************************
C
          DIMENSION GRID1(3500)
          DIMENSION DASH(3)
C
          DATA CHAR/' '/
          DATA DASH/3*0.1/
C
         DIMENSION QNP1X(367),X1(367),ACTUAL(366),ACTPLT(366)
C
         INTEGER*2 UFLAG,ACTFLG
C
C         WRITE(6,1000)
C1000     FORMAT(' SUBROUTINE PLOT ENTERED')
C
C         SCALE ACTUAL AND PREDICTED STREAM FLOW IF IN ENG. UNITS
C
C
         DO 5 I=1,ND
C          QNP1X(I)=QNP1X(I)/100.
           ACTPLT(I)=ACTUAL(I)
    5    CONTINUE
C
         IF(UFLAG.EQ.1) GO TO 120
         GO TO 130
  120    DO 7 I=1,ND
           QNP1X(I)=QNP1X(I)/100.
           ACTPLT(I)=ACTUAL(I)/100.
    7    CONTINUE
         GO TO 131
  130    CONTINUE
         DO 6 I2=1,ND
           ACTPLT(I2)=ACTUAL(I2)
    6    CONTINUE
C
C         SET UP PLOT FOR NUMBER OF DAYS .LE. 100
C
  131    IF(ND.LE.100) GO TO 10
         GO TO 20
   10    CONTINUE
         WRITE(6,8)
         CALL PLOT1(0,10,10,10,10)
         CALL PLOT2(GRID1,100.,0.,50.,0.)
C        ND1=ND-1
         CALL PLOT3('*',X1(1),QNP1X(1),ND)
         IF(ACTFLG.EQ.0) GO TO 11
         CALL PLOT3('.',X1,ACTPLT,ND)
   11    IF(UFLAG.EQ.0) CALL PLOT4(18,'CUBIC METERS/SEC')
         IF(UFLAG.EQ.1) CALL PLOT4(28,'CUBIC FEET/SEC SCALED BY 100')
         WRITE(6,9)
    9    FORMAT(//30X,'*=COMPUTED    .=ACTUAL')
         WRITE(6,8)
    8    FORMAT('C',///////)
   20    CONTINUE
C
```

```
C        SET UP PLOTS FOR NUMBER OF DAYS .LE. 200
C
         IF(ND.GT.100.AND.ND.LE.200) GO TO 30
         GO TO 40
   30    CONTINUE
         WRITE(6,8)
         CALL PLOT1(0,10,10,10,10)
         CALL PLOT2(GRID1,100.,0.,50.,0.)
         CALL PLOT3('*',X1(1),QNP1X(1),100)
         IF(ACTFLG.EQ.0) GO TO 35
         CALL PLOT3('.',X1,ACTPLT,100)
   35    IF(UFLAG.EQ.0) CALL PLOT4(18,'CUBIC METERS/SEC')
         IF(UFLAG.EQ.1) CALL PLOT4(28,'CUBIC FEET/SEC SCALED BY 100')
         WRITE(6,9)
         WRITE(6,8)
C
C        PLOT DAYS BETWEEN 100 AND 200
C
         CALL PLOT1(0,10,10,10,10)
         CALL PLOT2(GRID1,200.,100.,50.,0.)
         ND1=(ND-100)+1
         CALL PLOT3('*',X1(100),QNP1X(100),ND1)
         IF(ACTFLG.EQ.0) GO TO 45
C        ND2=(ND-100)+1
         CALL PLOT3('.',X1(100),ACTPLT(100),ND1)
   45    IF(UFLAG.EQ.0) CALL PLOT4(18,'CUBIC METERS/SEC')
         IF(UFLAG.EQ.1) CALL PLOT4(28,'CUBIC FEET/SEC SCALED BY 100')
         WRITE(6,9)
         WRITE(6,8)
   40    CONTINUE
C
C        SET UP PLOTS FOR NUMBER OF DAYS .LE. 300
C
         IF(ND.GT.200.AND.ND.LE.300) GO TO 50
         GO TO 60
   50    CONTINUE
         WRITE(6,8)
         CALL PLOT1(0,10,10,10,10)
         CALL PLOT2(GRID1,100.,0.,50.,0.)
         CALL PLOT3('*',X1(1),QNP1X(1),100)
         IF(ACTFLG.EQ.0) GO TO 55
         CALL PLOT3('.',X1,ACTPLT,100)
   55    IF(UFLAG.EQ.0) CALL PLOT4(18,'CUBIC METERS/SEC')
         IF(UFLAG.EQ.1) CALL PLOT4(28,'CUBIC FEET/SEC SCALED BY 100')
         WRITE(6,9)
         WRITE(6,8)
C
C        PLOT BETWEEN DAYS 100 AND 200
C
         CALL PLOT1(0,10,10,10,10)
         CALL PLOT2(GRID1,200.,100.,50.,0.)
         CALL PLOT3('*',X1(100),QNP1X(100),101)
         IF(ACTFLG.EQ.0) GO TO 65
         CALL PLOT3('.',X1(100),ACTPLT(100),101)
   65    IF(UFLAG.EQ.0) CALL PLOT4(18,'CUBIC METERS/SEC')
         IF(UFLAG.EQ.1) CALL PLOT4(28,'CUBIC FEETS/SEC SCALED BY 100.')
         WRITE(6,9)
         WRITE(6,8)
C
C        PLOT DAYS BETWEEN 200 AND 300
C
         CALL PLOT1(0,10,10,10,10)
         CALL PLOT2(GRID1,300.,200.,50.,0.)
         ND1=(ND-200)+1
         CALL PLOT3('*',X1(200),QNP1X(200),ND1)
         IF(ACTFLG.EQ.0) GO TO 75
C        ND2=(ND-200)+1
         CALL PLOT3('.',X1(200),ACTPLT(200),ND1)
   75    IF(UFLAG.EQ.0) CALL PLOT4(18,'CUBIC METERS/SEC')
         IF(UFLAG.EQ.1) CALL PLOT4(28,'CUBIC FEET/SEC SCALED BY 100.')
         WRITE(6,9)
         WRITE(6,8)
   60    CONTINUE
C
C        SET UP PLOTS FOR NUMBER OF DAYS BETWEEN 300 AND 365
C
         IF(ND.GT.300.AND.ND.LE.366) GO TO 70
         GO TO 80
   70    CONTINUE
         WRITE(6,8)
         CALL PLOT1(0,10,10,10,10)
         CALL PLOT2(GRID1,100.,0.,50.,0.)
         CALL PLOT3('*',X1(2),QNP1X(2),99)
         IF(ACTFLG.EQ.0) GO TO 85
         CALL PLOT3('.',X1,ACTPLT,100)
   85    IF(UFLAG.EQ.0) CALL PLOT4(18,'CUBIC METERS/SEC')
         IF(UFLAG.EQ.1) CALL PLOT4(28,'CUBIC FEET/SEC SCALED BY 100.')
         WRITE(6,9)
         WRITE(6,8)
C
```

```
C        PLOT BETWEEN 100 AND 200 DAYS
C
        CALL PLOT1(0,10,10,10,10)
        CALL PLOT2(GRID1,200.,100.,50.,0.)
        CALL PLOT3('*',X1(100),QNP1X(100),101)
        IF(ACTFLG.EQ.0) GO TO 95
        CALL PLOT3('.',X1(100),ACTPLT(100),101)
   95   IF(UFLAG.EQ.0) CALL PLOT4(18,'CUBIC METERS/SEC')
        IF(UFLAG.EQ.1) CALL PLOT4(28,'CUBIC FEET/SEC SCALED BY 100.')
        WRITE(6,9)
        WRITE(6,8)
C
C        PLOT BETWEEN 200 AND 300 DAYS
C
        CALL PLOT1(0,10,10,10,10)
        CALL PLOT2(GRID1,300.,200.,50.,0.)
        CALL PLOT3('*',X1(200),QNP1X(200),101)
        IF(ACTFLG.EQ.0) GO TO 105
        CALL PLOT3('.',X1(200),ACTPLT(200),101)
  105   IF(UFLAG.EQ.0) CALL PLOT4(18,'CUBIC METERS/SEC')
        IF(UFLAG.EQ.1) CALL PLOT4(28,'CUBIC FEET/SEC SCALED BY 100')
        WRITE(6,9)
        WRITE(6,8)
C
C        PLOT BETWEEN 300 AND 365 DAYS
C
        CALL PLOT1(0,10,10,10,10)
        CALL PLOT2(GRID1,400.,300.,50.,0.)
        ND1=(ND-300)+1
        CALL PLOT3('*',X1(300),QNP1X(300),ND1)
        IF(ACTFLG.EQ.0) GO TO 115
C       ND2=(ND-300)+1
        CALL PLOT3('.',X1(300),ACTPLT(300),ND1)
  115   IF(UFLAG.EQ.0) CALL PLOT4(18,'CUBIC METERS/SEC')
        IF(UFLAG.EQ.1) CALL PLOT4(28,'CUBIC FEET/SEC SCALED BY 100')
        WRITE(6,9)
        WRITE(6,8)
   80   CONTINUE
         RETURN
         END
```

```
1
      SUBROUTINE PRPLOT
C   PETE SMIDINGER   SUMMER 1966  MATH & COMP BR  GSFC  NASA
      IMPLICIT  LOGICAL*1(W), LOGICAL*1(K)
      DIMENSION  NSCALE(5),ABNOS(26),X(1),Y(1)
      LOGICAL*1 NOS(10)/'0','1','2','3','4','5','6','7','8','9'/
      LOGICAL*1  IMAGE(1),CH,LABEL(1)
      LOGICAL*1   VC      ,HC/'-'/,NC/'+'/,BL/' '/
     L          , HF/'F'/,HF1/'.'/,HF2/','/
      DATA VC/'I'/
C     DATA VC/Z4F/
      LOGICAL*1  FOR1(19)/'(1XA1,F8. ,1X121A1)'/
     L          ,FOR2(15)/'(1XA1, 9X121A1)'/
     L          ,FOR3(19)/'(1HOF  . ,  F   . )'/
      DATA KPLOT1 /.FALSE./, KPLOT2/.FALSE./
      DATA  KABSC,KORD,KBOTOL /3*.FALSE./
C
      ENTRY PLOT1(NSCALE,NHL,NSBH,NVL,NSBV)
      KPLOT1=.TRUE.
      KPLOT2=.FALSE.
125   NH=IABS(NHL)
      NSH=IABS(NSBH)
      NV=IABS(NVL)
      NSV=IABS(NSBV)
      NSCL=NSCALE(1)
      IF(NH*NSH*NV*NSV.NE.0) GO TO 128
      WRITE (6,14)
14    FORMAT(T5,'SOME PLOT1 ARG. ILLEGALLY 0')
      KPLOT=.FALSE.
      RETURN
128   KPLOT=.TRUE.
      IF(NV.LE.25) GO TO 126
      WRITE (6,12)
      KPLOT=.FALSE.
12    FORMAT(T5,'NO. OF VERTICAL LINES >25')
      RETURN
126   CONTINUE
      NVM=NV-1
      NVP=NV+1
      NDH=NH*NSH
      NDHP=NDH+1
      NDV=NV*NSV
      NDVP=NDV+1
      NIMG=(NDHP*NDVP)
      IF(NDV.LE.120) GO TO 130
      KPLOT=.FALSE.
      WRITE (6,11)
11    FORMAT(T5,'WIDTH OF GRAPH >121')
      RETURN
130   CONTINUE
      IF(NSCL.EQ.0) GO TO 70
      FSY=10.**NSCALE(2)
      FSX=10.**NSCALE(4)
      IY=MIN0(IABS(NSCALE(3)),7)+1
      IX=MIN0(IABS(NSCALE(5)),9)+1
      GO TO 75
70    FSY=1.
      FSX=1.
      IY=4
      IX=4
        IF(.NOT. KPLOT2) GO TO 75
        XI=MAX1(ABS(XMAX),ABS(YMAX),ABS(XMIN),ABS(YMIN))
        IP=XI
        IF(IP .GT. 99999) IY=1
```

```
        IF(IP .GT.  9999) IY=2
        IF(IP .GT.   999) IY=3
 75     FOR1(10)=NOS(IY)
        NA=MIN0(IX,NSV)-1
        NS=NA-MIN0(NA,120-NDV)
        NB=11-NS+NA
        I1=NB/10
        I2=NB-I1*10
        FOR3(6)=NOS(I1+1)
        FOR3(7)=NOS(I2+1)
        FOR3(9)=NOS(NA+1)
        IF(NV.GT.0) GO TO 90
        DO 80 J=11,18
 80     FOR3(J)=BL
        GO TO 100
 90     I1=NV/10
        I2=NV-I1*10
        FOR3(11)=NOS(I1+1)
        FOR3(12)=NOS(I2+1)
        FOR3(13)=HF
        I1=NSV/100
        I3=NSV-I1*100
        I2=I3/10
        I3=I3-I2*10
        FOR3(14)=NOS(I1+1)
        FOR3(15)=NOS(I2+1)
        FOR3(16)=NOS(I3+1)
        FOR3(17)=HF1
        FOR3(18)=FOR3(9)
 100    IF(KPLOT1) RETURN
        KPLOT1=.TRUE.
C
        ENTRY PLOT2(IMAGE,XMAX,XMIN,YMAX,YMIN)
        KPLOT2=.TRUE.
        IF(KPLOT1) GO TO 210
        NSCL=0
        NH=5
        NSH=10
        NV=10
        NSV=10
        GO TO 128
 210    CONTINUE
        IF(.NOT.KPLOT)RETURN
        YMX=YMAX
        DH=(YMAX-YMIN)/FLOAT (NDH)
        DV=(XMAX-XMIN)/FLOAT(NDV)
        DO 220 I=1,NVP
 220    ABNOS(I)=(XMIN+FLOAT((I-1)*NSV)*DV)*FSX
        DO 225 I=1,NIMG
 225    IMAGE(I)=BL
        DO 240 I=1,NDHP
        I2=I*NDVP
        I1=I2-NDV
        KNHOR=MOD(I-1,NSH).NE.0
        IF(KNHOR) GO TO 230
        DO 228 J=I1,I2
 228    IMAGE(J)=HC
 230    CONTINUE
        DO 240 J=I1,I2,NSV
        IF(KNHOR) GO TO 235
        IMAGE(J)=NC
        GO TO 240
```

```
235    IMAGE(J)=VC
240    CONTINUE
       XMIN1=XMIN-DV/2.
       YMIN1=YMIN-DH/2.
       RETURN
C
       ENTRY PLOT3(CH,X,Y,N3)
300    IF(KPLOT2) GO TO 312
301    WRITE (6,13)
13     FORMAT(T5,'PLOT2 MUST BE CALLED')
312    CONTINUE
       IF(.NOT.KPLOT) RETURN
       IF(N3.GT.0) GO TO 314
       KPLOT=.FALSE.
       WRITE (6,15)
15     FORMAT(T5,'PLOT3, ARG2 < 0')
       RETURN
314    DO 320 I=1,N3
       DUM1=(X(I)-XMIN1)/DV
       DUM2=(Y(I)-YMIN1)/DH
       IF(DUM1.LT.0..OR.DUM2.LT.0.) GO TO 320
       IF(DUM1.GE.NDVP.OR.DUM2.GE.NDHP) GO TO 320
       NX=1+INT(DUM1)
       NY=1+INT(DUM2)
315    J=(NDHP-NY)*NDVP+NX
       IMAGE(J)=CH
320    CONTINUE
       RETURN
C
       ENTRY PLOT4(NL,LABEL)
       ENTRY FPLOT4(NL,LABEL)
       IF(.NOT.KPLOT) RETURN
       IF(.NOT.KPLOT2) GO TO 301
       DO 420 I=1,NDHP
       IF(I.EQ.NDHP.AND.KBOTGL) GO TO 420
       WL=BL
       IF(I.LE.NL) WL=LABEL(I)
       I2=I*NDVP
       I1=I2-NDV
       IF(MOD(I-1,NSH).EQ.0.AND..NOT.KORD) GO TO 410
       WRITE (6,FOR2) WL,(IMAGE(J),J=I1,I2)
       GO TO 420
410    CONTINUE
       ORDNO=(YMX-FLOAT(I-1)*DH)*FSY
       WRITE (6,FOR1) WL,ORDNO,(IMAGE(J),J=I1,I2)
420    CONTINUE
       IF(KABSC) GO TO 430
       WRITE (6,FOR3) (ABNOS(J),J=1,NVP)
430    RETURN
C
       ENTRY OMIT(LSW)
       KABSC=MOD(LSW,2).EQ.1
       KORD=MOD(LSW,4).GE.2
       KBOTGL=LSW.GE.4
       RETURN
C
       ENTRY PLTAPE(ITAPE)
C         NOT YET
       RETURN
       END
END OF DATA
```

APPENDIX C
DETAILS OF TEMPERATURE PREPROCESSING SUBROUTINE PRETMP

Table C–1

Parameter	Common	Type	Units Metric	Units English	Description
TMAX1	TBASE	R*4	°C	°F	Maximum temperature at station #1
TMIN1	TBASE	R*4	°C	°F	Minimum temperature at station #1
TMAX2	TBASE	R*4	°C	°F	Maximum temperature at station #2
TMIN2	TBASE	R*4	°C	°F	Minimum temperature at station #2
THOUR1	TBASE	R*4	°C	°F	Hourly temperatures from station #1
THOUR2	TBASE	R*4	°C	°F	Hourly temperatures from station #1
T1	TBASE	R*4	°C	°F	Temperatures in degrees/degree-days from station #1
T2	TBASE	R*4	°C	°F	Temperatures in degrees/degree-days from station #2
DTLR	BASDAT	R*4	°C/100m	°F/1000ft	Average temperature lapse rate in degree-days
ZMEAN	TBASE	R*8	m	ft	Hypsometric mean elevation of each zone
STATN	TBASE	R*8	m	ft	Mean elevation of each base station
NSTATN	TBASE	I*4	—	—	Number of base stations
MAXMIN	TBASE	I*2	—	—	Flag to indicate if temperatures are maximum-minimum. 0 = Not MAX–MIN 1 = MAX–MIN
ND	CLIDAT	I*4	Days	Days	Number of snowmelt days
NZ	BASDAT	I*4	—	—	Number of elevation zones
UFLAG	OPTDAT	I*2	—	—	Units option flag 0 = Metric units 1 = English Units
MTHD	OPTDAT	I*2	—	—	Degree-day temperature computation flag 0 = Mean method 1 = Effective minimum
IEXT	TBASE	I*2	—	—	Flag indicates how temperatures are to be extrapolated to elevation zone 0 = Extrapolate using predetermined constant 1 = Automatically extrapolate using lapse rate

Table C–1 (cont.)

Parameter	Common	Type	Units Metric	Units English	Description
IDEGDY	TBASE	I*2	—	—	Flag to indicate if temperatures are to be computed in degree-days. 0 = Do not compute 1 = Compute temps in degree-days
ITZ	TBASE	I*2	—	—	Flag to indicate if temperatures are from single zone or all zones 0 = All zones 1 = Single zone
IHOUR	TBASE	I*2	—	—	Flag to indicate if temperatures are input hourly 0 = No hourly temperatures 1 = Hourly temperatures

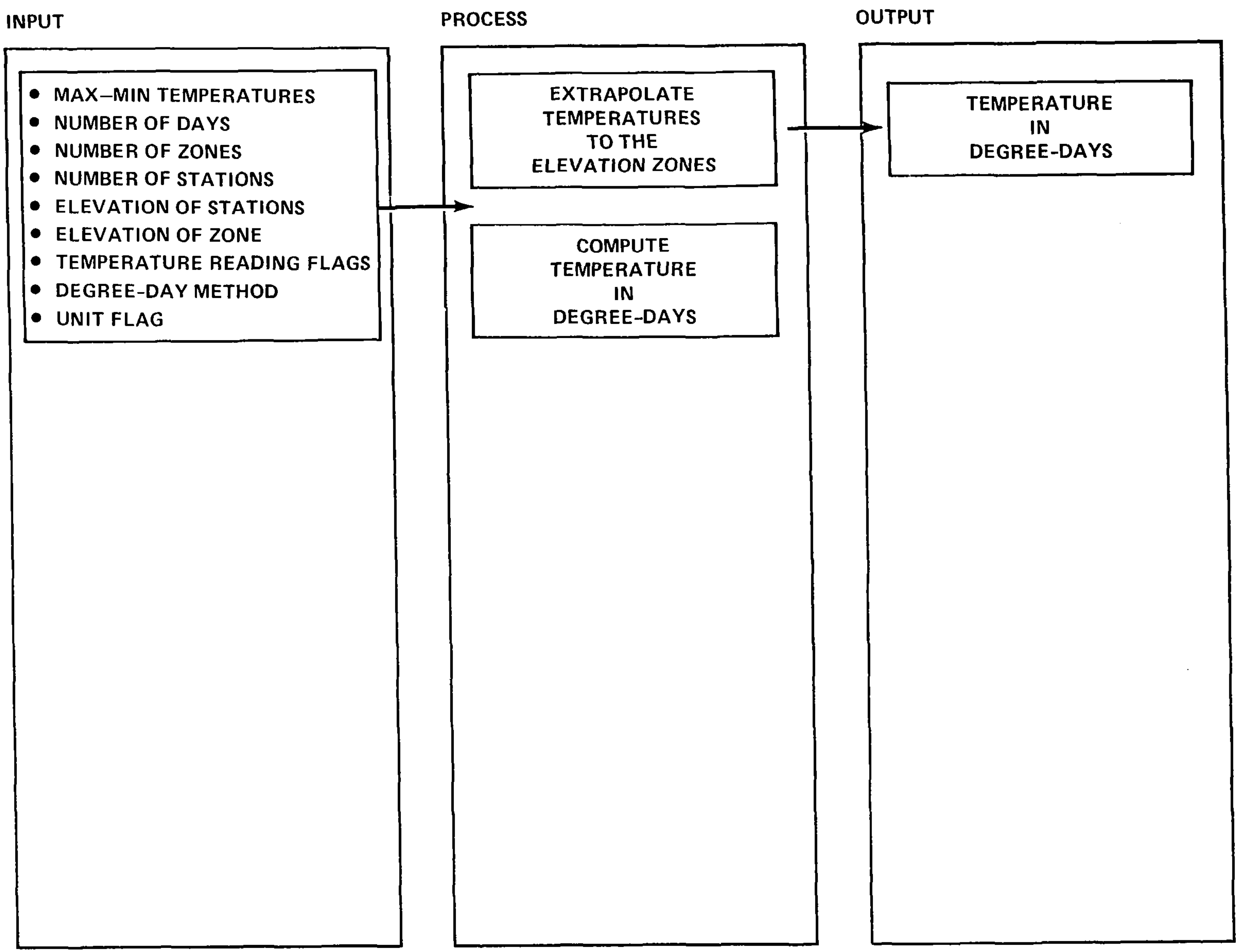

Figure C–1. Process-oriented flow chart for PRETMP.

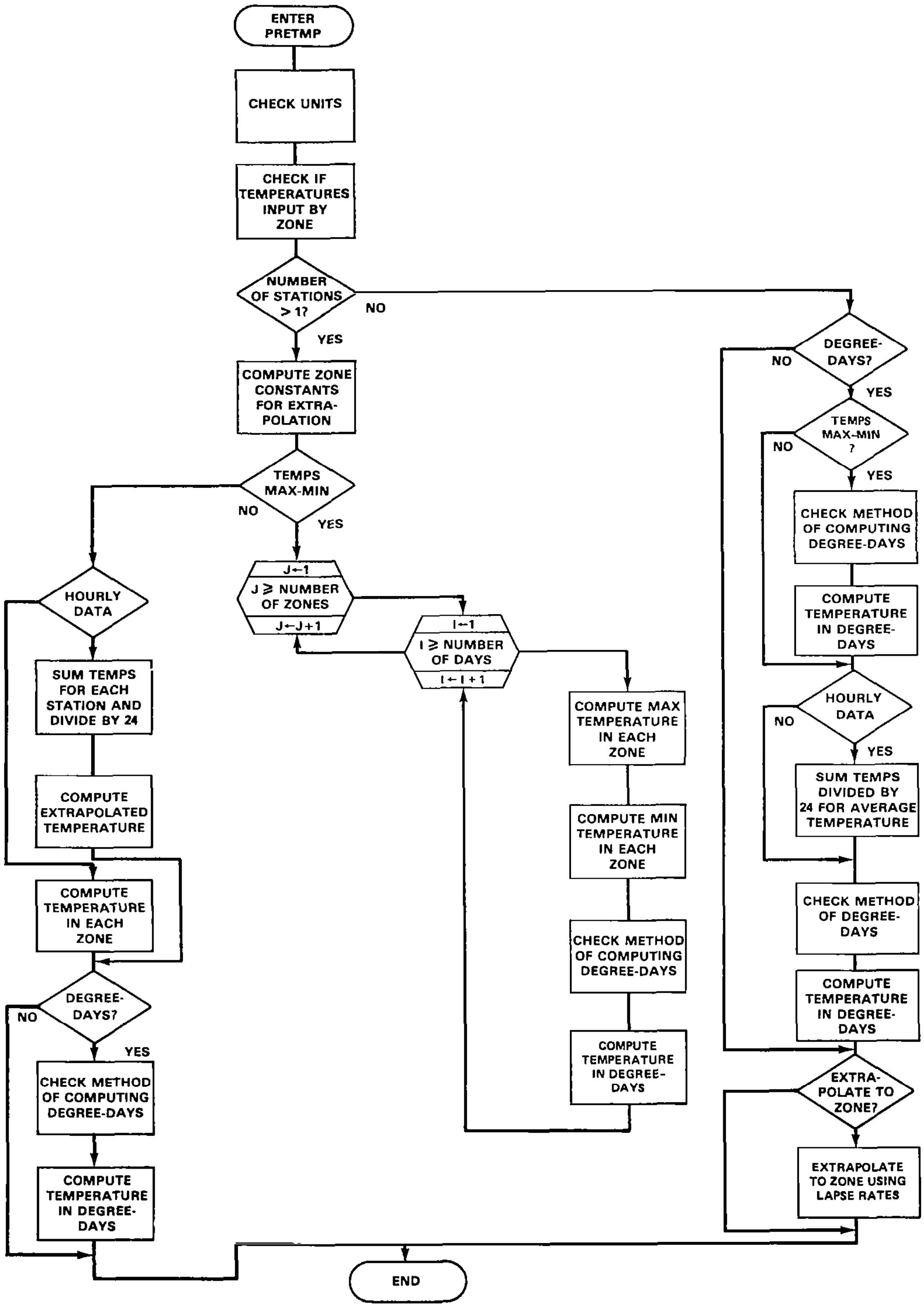

Figure C–2. Flow diagram for subroutine PRETMP.

```
      SUBROUTINE PRETMP(STATN,ND,NZ,ITMAX,ITMIN,TEMPT,TMAX1,TMIN1,
     1 TMAX2,TMIN2,DTLR,UFLAG,MTHD,ZMEAN,NSTATN,IEXT,IDEGDY,T)
C
C*************************************************************************
C
C       FUNCTION - PRETMP IS A MODULAR TEMPERATURE PREPROCESSING ROUTINE
C                  TAKES MAX-MIN DAILY TEMPERATURES IN DEGREES FROM
C                  EACH STATION AND EXTRAPOLATES THE TEMPERATURE TO
C                  THE ZONE AND COMPUTES THE TEMPERATURE IN DEGREE-DAYS.
C                  DEGREE-DAYS CAN BE COMPUTED BY ONE OF TWO METHODS
C                  AS MEAN OR EFFECTIVE MINIMUM. TEMPERATURES CAN BE
C                  INPUT AS SINGLE STATION VALUES OR AS HOURLY
C                  TEMPERATURES.
C
C
C       ARGUMENT LIST
C       VARIABLE   TYPE  IO  DESCRIPTION
C       --------   ----  --  -----------
C       STATN      R*8   I   ELEVATION OF RECORDING STATION
C       ND         I*4   I   NUMBER OF SNOWMELT DAYS
C       NZ         I*4   I   NUMBER OF ZONES
C       ITMAX      I*4   I   DAY MAX TEMP IS RECORDED FOR EACH STATION
C       ITMIN      I*4   I   DAY MIN TEMP IS RECORDED FOR EACH STATION
C       TMAX1      R*4   I   MAX TEMPERATURE FOR STATION 1
C       TMIN1      R*4   I   MIN TEMPERATURE FOR STATION 1
C       TMAX2      R*4   I   MAX TEMPERATURE FOR STATION 2
C       TMIN2      R*4   I   MIN TEMPERATURE FOR STATION 2
C       UFLAG      I*2   I   UNITS FLAG(ENGLISH OR METRIC)
C       MTHD       I*2   I   METHOD OF COMPUTING DEGREE DAYS
C                            (EFFECTIVE MINIMUM OR MEAN)
C       ZMEAN      R*8   I   HYPSOMETRIC MEAN ELEVATION OF EACH ZONE
C       NSTATN     I*2   I   NUMBER OF TEMPERATURE RECORDING STATIONS
C       IEXT       I*2   I   FLAG TO EXTRAPOLATE TO ELEVATION ZONES
C       IDEGDY     I*2   I   FLAG TO COMPUTE DEGREE-DAYS
C       T          R*4    O  COMPUTED TEMPERATURE IN DEGREE DAYS
C
C       EXTERNAL REFERENCES -- NONE.
C
C       CALLED BY -- MAIN (DRVSNO)
C
C       COMPUTER/LANGUAGE - IBM 360/91 AT GSFC/FORTRAN IV
C
C       DESIGNER/PROGRAMMER - G.MAJOR,RESEARCH & DATA SYSTEMS,INC.
C
C*************************************************************************
C
C
C
      DIMENSION ZCONST(8),ARENAM(8)
      DIMENSION STATN(2),ITMAX(2),ITMIN(2),TMAX1(365),TMIN1(365),
     1 TMAX2(365),TMIN2(365),ZMEAN(8),T(365,8),DTLR(365,8),TEMPT(365,8)
C
      REAL*8 ZMEAN,STATN,ZCONST,STAINT
      INTEGER*2 ITMAX,ITMIN,MTHD,ITPROC,UFLAG,NSTATN,IEXT,IDEGDY
C
C
      IF(UFLAG.EQ.0) TU=0.
      IF(UFLAG.EQ.1) TU=32.
C
C
C      CHECK NUMBER OF STATIONS
C
      IF(NSTATN.EQ.1) GO TO 900
C
```

Figure C–3. Source listing for subroutine PRETMP.

```
C        CALCULATE ZONE CONSTANTS BASED ON HYPSOMETRIC MEAN ELEVATION
C        OF ZONE AND ELEVATION OF STATION
C
        STAINT=STATN(1)-STATN(2)
        DO 10 I=1,NZ
          ZCONST(I)=(ZMEAN(I)-STATN(1))/STAINT
   10   CONTINUE
C
C        CHECK UNITS
C
C
C        CALCULATE TEMPERATURE IN DEGREE-DAYS FOR EACH ZONE
C
        DO 30 J=1,NZ
          DO 20 I=1,ND
C
C         CHECK WHICH TEMPERATURE READINGS BELONG TO WHICH DAY FOR EACH
C         STATION. IF ITMP IS 1 THEN THE READING IS FOR CURRENT DAY.
C         IF ITMP IS 2 THEN THE READING IS FOR NEXT DAY.
C
        IF(ITMAX(1).EQ.1) IX=I
        IF(ITMAX(1).EQ.2) IX=I+1
        IF(ITMAX(2).EQ.1) I2X=I
        IF(ITMAX(2).EQ.2) I2X=I+1
C
        IF(ITMIN(1).EQ.1) IM=I
        IF(ITMIN(1).EQ.2) IM=I+1
        IF(ITMIN(2).EQ.1) I2M=I
        IF(ITMIN(2).EQ.2) I2M=I+1
C
C        COMPUTE MAX AND MIN TEMPERATURES FOR EACH ZONE
C
        TMAX=ZCONST(J)*(TMAX1(IX)-TMAX2(I2X))
C
        TMX=TMAX1(IX)+TMAX
C        NOTE: SOUTH FORK BASIN PROCESSING ONLY
C
        IF(J.EQ.3) GO TO 40
        GO TO 41
   40   IF(TMX.GT.TMAX2(I2X)) TMX=TMAX2(I2X)
   41   CONTINUE
        TMIN=ZCONST(J)*(TMIN1(IM)-TMIN2(I2M))
        TMN=TMIN1(IM)+TMIN
C
CC        NOTE: SOUTH FORK BASIN PROCESSING ONLY
C
        IF(J.EQ.3) GO TO 42
        GO TO 43
   42   IF(TMN.GT.TMIN2(I2M)) TMN=TMIN2(I2M)
   43   CONTINUE
C
C       CHECK METHOD OF COMPUTING DEGREE-DAYS. IF MTHD IS 1 THEN USE
C       EFFECTIVE MINIMUM METHOD. IF MTHD IS 0 USE MEAN METHOD.
C
        IF(MTHD.EQ.1) GO TO 35
        IF(MTHD.EQ.0) GO TO 25
C
   35   IF(UFLAG.EQ.0.AND.TMN.LT.0.) TMN=0.
        IF(UFLAG.EQ.1.AND.TMN.LT.32.) TMN=32.
C
C        COMPUTE TEMPERATURE IN DEGREE-DAYS
C
   25     TEMPT(I,J)=((TMX+TMN)/2.)-TU
          IF(TEMPT(I,J).LT.0.) TEMPT(I,J)=0.
```

Figure C-3. (Continued)

```
   20     CONTINUE
   30   CONTINUE
        GO TO 990
  900   CONTINUE
C
C        CHECK IF TEMPERATURE IS TO BE COMPUTED IN DEGREE-DAYS
C
        IF(IDEGDY.EQ.0) GO TO 590
C
C        CHECK IF TEMPERATURES ARE MAX-MIN
C
        IF(ITMAX(1).EQ.0) GO TO 52
C
C        CHECK METHOD OF COMPUTING DEGREE DAYS
C
        DO 600 I=1,ND
          IF(MTHD.EQ.1) GO TO 22
          IF(MTHD.EQ.0) GO TO 23
   22     IF(UFLAG.EQ.0.AND.TMIN1(I).LT.0.) TMIN1(I)=0.0
          IF(UFLAG.EQ.1.AND.TMIN1(I).LT.32.) TMIN1(I)=32.0
C        COMPUTE TEMPERATURE IN DEGREE DAYS
C
   23     T(I,1)=((TMAX1(I)+TMIN1(I))/2.)-TU
C         IF(T(I,1).LT.0.0) T(I,1)=0.0
  600   CONTINUE
C
          GO TO 590
   52    CONTINUE
         DO 605 I=1,ND
           IF(MTHD.EQ.1) GO TO 53
           IF(MTHD.EQ.0) GO TO 54
   53      IF(UFLAG.EQ.0.AND.T(I,1).LT.0.) T(I,1)=0.
           IF(UFLAG.EQ.1.AND.T(I,1).LT.32.) T(I,1)=32.
   54      T(I,1)=T(I,1)-TU
  605    CONTINUE
  590   CONTINUE
C
C        CHECK IF TEMPERATURE IS TO BE AUTOMATICALLY EXTRAPOLATED TO
C        ELEVATION ZONE. IF NOT, USE THE LAPSE RATES GIVEN AS INPUT
C
        IF(IEXT.EQ.0) GO TO 950
        IF(UFLAG.EQ.0) ZCON=100.
        IF(UFLAG.EQ.1) ZCON=1000.
        DO 602 J=1,NZ
          ZCONST(J)=STATN(1)-ZMEAN(J)
          DO 601 I=1,ND
            TEMPT(I,J)=T(I,1)+(ZCONST(J)/ZCON)*DTLR(I,1)
  601     CONTINUE
  602   CONTINUE
        GO TO 990
  950   CONTINUE
C
C        EXTRAPOLATE TEMPERATURES USING THE GIVEN LAPSE RATES
C
        DO 603 J=1,NZ
          DO 604 I=1,ND
            TEMPT(I,J)=T(I,1)+DTLR(I,J)
  604     CONTINUE
  603   CONTINUE
C
  990    RETURN
```

Figure C-3. (Continued)

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15. Supplementary Notes

J. Martinec: Federal Institute for Snow and Avalanche Research, Weissfluhjoch/Davos, Switzerland.
A. Rango: Goddard Space Flight Center, Greenbelt, Maryland.
E. Major: Research and Data Systems, Inc., Lanham, Maryland.

16. Abstract

The purpose of this manual is to provide a means by which a user may apply the snowmelt-runoff model (SRM) unaided. To this effect, model structure, conditions of application, and data requirements, including remote sensing, are described. Guidance is given for determining various model variables and parameters. Possible sources of error are discussed and conversion of SRM from the simulation mode to the operational forecasting mode is explained. A computer program is presented for running SRM which should be easily adaptable to most systems used by water resources agencies.

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