IV.2.2-SNOW-17 INITIAL PARAMETER VALUES FOR THE HYDRO-17 SNOW MODEL

Bookmarks

Contents

[Next] [Previous] [Bookmarks] [Top]

Introduction

This Section contains guidelines for determining initial parameter values for the snow accumulation and ablation model.

It discusses the relationship between each snow model parameter and various climatic and physiographic factors which affect snow accumulation and ablation

A description of the SNOW-17 snow model is in Chapter II.2 [Hyperlink].

Information about appropriate initial values of many of the soil moisture accounting model parameters can be obtained from an analysis of the daily discharge hydrograph. However the hydrograph is not very helpful when one is trying to determine initial estimates of the values of the snow model parameters. The snow model parameters are mainly related to various climatic and physiographic factors which affect snow accumulation and ablation. Thus the user needs information on typical meteorological and snow cover conditions as well as the physiographic characteristics of the area. This subsection discusses what is known about the relationship between climatic and physiographic factors and the value of each of the snow model parameters. From this discussion and a knowledge of the area the user should be able to determine reasonable initial values for the snow model parameters.

[Next] [Previous] [Bookmarks] [Top]

Major Parameters

As discussed in Chapter II-2-SNOW-17 [Hyperlink] these are the parameters which typically have the greatest effect on the simulation results. Since most of the effort during the calibration of the snow model will likely be devoted to determining the proper value of these parameters it is important to start with reasonable values.

[Next] [Previous] [Bookmarks] [Top]

1. **SCF** - The snow correction factor for a given precipitation gage depends primarily on the wind speed at the gage site and whether the gage is equipped with a wind shield. The wind speed at the gage site is partly dependent on general surface winds but is also heavily influenced by the exposure of the gage.

   Section IV.1.2-MAT [Hyperlink] contains a more detailed discussion of the causes and magnitudes of snowfall catch deficiencies at a single precipitation gage.

   The SCF parameter in the snow model is a mean gage catch deficiency correction factor. If the precipitation input is based on a single gage which is reasonably representative of the point or area to which the model is being applied then an initial estimate of the value of SCF can be obtained from information on typical wind speeds during snowfall at the gage site. However normally the precipitation input is a weighted estimate computed by the MAP procedure using data from a number of precipitation gages. Thus a knowledge of the exposure at each site as well as information on typical surface wind speeds during snowfall are needed to estimate SCF from a plot of catch deficiency versus wind speed at the gage site. Surface wind data are available but in some mountainous areas it may be difficult to find a representative station. Information on exposure is usually available only from someone with a personal knowledge of the station location.

   Another method of getting an initial estimate of SCF is by using a pair of precipitation gages which are nearly identical in terms of average annual precipitation and exposure at each site but differ in that one is equipped with a wind shield. Since a wind shield has little effect when it rains the measured amounts of precipitation should be similar during months when snowfall seldom occurs. During months when the precipitation is predominantly snow the shielded gage should catch a greater amount. Since in general a shield can reduce solid precipitation measurement errors by about one-third to one-half an estimate of the actual precipitation and consequently of SCF can be computed from the difference in the catch of the shielded and unshielded gages. The problem is that pairs of gages which satisfy the criteria for using this method do not exist in many areas.

The information needed to estimate the initial value of SCF by either of the preceding methods may not be readily available or the user may decide that such analyses are not warranted. In such a case a reasonable default value for SCF is 1.2. This value corresponds to a somewhat protected site with moderate winds during snowfall which is typical of many climatological data stations. Sites that are well protected or experience little wind during snowfall would have values of SCF closer to 1.0. Poorly protected or windy sites would typically have values of SCF considerably above 1.2.

It should be remembered when selecting an initial value of SCF that this parameter implicitly accounts for gains or losses in water-equivalent caused by several processes that are not included in the snow model. The processes are vapor transfer, interception and drifting. If the user knows or has a strong suspicion that the gain or loss due to any of these processes is significant this should be reflected in the initial value of SCF.

[Next] [Previous] [Bookmarks] [Top]

2. **MFMAX and MFMIN** - Various types of melt-factors have been used for years. Most of these melt factors are used to compute the change in water-equivalent of the snow cover rather than surface snowmelt. In addition most melt factors are based on a daily time interval rather than the 6 hour interval used in the NWSRFS. The typical degree-day factor implicitly attempts to account for the ripening of the snow cover, nighttime heat losses during the melt season and sometimes even the areal extent of the snow cover. For these reasons it is somewhat difficult to use regional relationships between the value of a degree-day melt factor and physiographic conditions to obtain an estimate of MFMAX and MFMIN. However if available such relationships can at least be helpful in estimating the relative difference between melt factors for areas with differing physiographic conditions.

   Surface snowmelt is affected by many climatic and physiographic factors. The factor which most commonly is used to classify melt factors is forest cover. This is because forest cover has a significant effect on many of the variables affecting snow cover energy exchange. Thus differences in forest cover can be used to explain much of the variation in melt rates from one area to another. Differences in aspect are also important especially when modeling snowmelt at a point. Over most watersheds or subareas the effects of differing aspects tend to cancel. Climatic factors are important in explaining differences in melt factors between regions when physiographic conditions are the same. For example melt factors in arctic areas tend to be smaller than those at lower latitudes with similar physiographic conditions mainly due to lower radiation intensities and relatively little wind during the melt season.

In areas with distinct accumulation and melt seasons the maximum melt factor is generally more critical than the minimum melt factor since most of the snow melts after March 21. Table 1 [Bookmark] gives some typical values for the melt factors as a function of forest cover conditions. Climatic and other physiographic factors will tend to alter these values and should be taken into account when making initial estimates of the melt factors. Melt factors should be increased in areas with predominantly south facing slopes and reduced in areas with a northerly aspect. Aspect should have more effect in open areas than forested areas. Windy areas typically have higher melt factors than areas where calm conditions prevail. In arctic areas the melt factors should be smaller than those at lower latitudes (Table 1 is based on applications of the model to the contiguous United States).

[Back]

Table 1. Typical values of melt factors as related to forest cover for areas with distinct accumulation and melt seasons (units are MM/DEGC/6HR)

Forest Cover	MFMAX	MFMIN
Coniferous forest - quite dense	0.5 - 0.8	0.2 - 0.3
Mixed forest - coniferous plus open and/or deciduous	0.8 - 1.0	0.25 - 0.4
Predominantly deciduous forest	1.0 - 1.3	0.35 - 0.5
Open areas	1.3 - 2.0	0.5 - 0.9

In areas with no distinct accumulation and melt seasons the maximum melt factors are generally similar to those given in Table 1. However the minimum melt factors are usually somewhat higher. This is because in such areas the snow cover is normally shallow and mid-winter thaws last long enough to completely ripen the snow surface. In areas with a distinct accumulation season winter thaw periods are usually brief and the albedo of the snow cover remains relatively high thus keeping MFMIN low.

Table 1 can also be used to get initial estimates of MFMAX and MFMIN at a point. However even though the point itself might be classified as open the surroundings should be taken into account. A snow course in a small forest clearing may act similar to a mixed forest whereas a snow course in a larger opening should be approaching the conditions at a truly open site.

[Next] [Previous] [Bookmarks] [Top]

3. **UADJ** - The wind function which was found to give the best results at the NOAA-ARS Snow Research Station [Anderson (1976)] can be used to obtain an initial estimate of UADJ. This wind function can be expressed as:

$$f(U1) = 0.002 * U1 \quad (1)$$

where f(U1) is the average wind function using measurements taken 1 M above the snow surface (MM/MB)
U1 is the wind movement at a height of 1 M (KM)

Thus the initial estimate of UADJ would be 0.002 multiplied by the average wind movement in kilometers for 6 hours at a height of one meter above the snow surface during a rain-on-snow event. For example if the average one meter wind speed during rain-on-snow events is estimated to be 6 KM/HR then the 6 hour wind movement is 36 KM and the estimate of UADJ is 0.072 MM/MB. In most cases values of UADJ range between about 0.03 and 0.19 MM/MB corresponding to one meter wind speeds of about 2.5 to 16 KM/HR (1.5 to 10 MPH). The lower values of UADJ are commonly associated with heavily forested watersheds while the higher values usually occur in generally open areas. However there are many exceptions thus it is best to base the initial estimate of UADJ on a knowledge of typical wind speeds during rain-on-snow events at the particular location being modeled.

[Next] [Previous] [Bookmarks] [Top]

4. **SI and the areal depletion curve** - The parameter SI and the areal depletion curve are related therefore initial estimates of both can be made at the same time. If a lot of data on both the mean water-equivalent of the snow cover and its areal extent were available SI and the areal depletion curve could be determined by plotting mean areal water-equivalent versus the areal extent of the snow cover for a number of years. Such an analysis would require a sufficient number of snow courses to represent snow cover conditions over the entire watershed. Photographs documenting the percent snow cover would also be helpful. Such data are rarely available in the United States.

   Without the detailed information needed to compute SI and the areal depletion curve the initial estimate of these parameters must be based on the user's knowledge of the typical variability in both the snow cover and melt rates over the area. If the snow cover is very uniform and melts at a uniform rate the area will remain at 100 percent cover until just before the snow disappears. In this case SI would be zero or nearly zero and the shape of the areal depletion curve would be unimportant. SI is always zero at a single point. It should be noted that even though a snow course is often referred to as a point it actually consists of a number of points. Some of the points usually are bare of snow before others. Thus a snow course can have a value of SI which is significantly greater than zero. At some snow courses snow cover conditions are very nonuniform because of drifting and/or differential melt rates.

   At the other extreme in some areas the snow cover is so variable that bare ground appears as soon as melt begins no matter how much snow is present. In such areas the value of SI is unimportant as long as it is greater than the largest value of the mean areal water-equivalent which could reasonably occur. The shape of the areal depletion curve is very important in such areas. However in most areas the snow cover remains at or near 100 percent cover for some time after active melt begins especially during the years with the largest accumulations of snow. Only after a significant portion of the snow cover has melted do sizable portions of bare ground appear. With a good knowledge of the typical progression of the state of the snow cover during ablation the user should be able to make a good estimate of the mean areal water-equivalent above which 100 percent cover generally exists. This would be the initial estimate of the parameter SI. Without such knowledge it is recommended that the initial value of SI be greater than the maximum water-equivalent that occurs during the calibration period. Thus initially the areal depletion curve would be used immediately whenever the snow begins to ablate. After a couple of calibration runs the user should be able to decide how long the snow cover should remain at 100 percent and adjust SI accordingly.

The shape of the areal depletion curve depends on the magnitude and distribution of variations in snow cover accumulation and snowmelt. The best way to give the user some insight into choosing the initial shape of the areal depletion curve is probably by discussing the physical meaning of curves of different shapes. Figure 1 [Bookmark] shows four areal depletion curves with differing shapes:

- Curve A indicates that bare ground appears at a continually increasing rate as the snow cover ablates. Such a curve is typical of areas in which there is variability in accumulation and melt but the variability is rather evenly scattered over the area.

- Curve B is similar to curve A in the beginning but at the lower end the rate at which bare ground appears is reversed. This reversal indicates that a portion of the area accumulates much more snow or has a significantly lower melt rate (or a combination of both factors) than the rest of the area. The reversal may be caused by forested areas with northerly aspects dense conifer stands within an area with generally mixed cover or large accumulations of snow in drifts, in ravines or at the higher elevations.

- Curve C is similar to curve A in the middle and at the lower end. In the beginning curve C indicates that the areal cover drops off very rapidly when ablation begins. This indicates that a portion of the area accumulates much less snow or has a much higher melt rate (or both) than the remainder. This may be caused by open areas with a southerly aspect open areas within a forest which consists mainly of conifers areas which are typically blown free of snow or little accumulation of snow at lower elevations.

- Curve D is for an area which can be basically divided into the two extremes, i.e., low accumulation and/or high melt rates and high accumulation and/or low melt rates. Normally if such a curve is required it would be preferable to subdivide the area and model each portion separately since they are so distinctly different.

Both curves C and D generally exist only in areas where the SI value is greater than the largest water-equivalent that occurs during most years. From this discussion and a knowledge of the area the user should be able to select an initial estimate of the areal depletion curve. If the area is properly subdivided the most common depletion curve is one similar in shape to curve B. However the position of the reversal point will vary from location to location.

[Next] [Previous] [Bookmarks] [Top]

Minor Parameters

As discussed in Chapter II.2-SNOW-17 [Hyperlink] these are parameters which normally can be determined in advance based on a knowledge of the typical climatic and snow cover conditions for the area. The initial estimates may require one or two slight adjustments but the determination of the appropriate values of these parameters should always be a small part of the calibration process. However for this to be so care must be taken in selecting the initial estimates of these minor parameters.

[Next] [Previous] [Bookmarks] [Top]

1. **NMF and TIPM** - These two parameters are partially interrelated. Thus the value of each parameter is somewhat dependent on the value assigned to the other. The most logical way of selecting initial values seems to be to assign a value to TIPM first and then select an appropriate estimate for the maximum negative melt factor NMF. If any adjustments are required during calibration NMF should be adjusted while TIPM should remain fixed. The procedure used in the model to compute energy exchange during non-melt periods is somewhat empirical plus it is a steady state approximation to a process where steady state conditions seldom occur. Thus the parameters cannot be computed directly from experimentally measured heat transfer coefficients for snow.

   Energy exchange during non-melt periods is assumed to be proportional to the temperature gradient defined by the snow surface temperature (approximated by the air temperature) and a temperature at some depth below the surface. The temperature of the snow at some depth below the surface is approximated by an antecedent temperature index ATI. The parameter TIPM is used in the computation of ATI. A value of TIPM above 0.5 essentially gives weight only to air temperatures during the past few 6 hour periods in the computation of ATI. A value of TIPM below 0.2 gives weight to temperatures over the past 3 to 7 days. Thus an ATI computed using a high value of TIPM would correspond to a snow temperature closer to the surface than an ATI based on a low value of TIPM. It seems logical to expect that heat transfer within a deep snow cover would be controlled by a temperature further below the surface than in the case of a shallow cover because of the increased depth and heat storage capacity. Thus it would be expected that the value of TIPM used for areas with typically deep snow covers should be smaller than the value of TIPM used for areas which generally have a shallow snow cover. This has been confirmed by calibration results. It is recommended that a value of TIPM of 0.5 or greater be used in areas which typically have a relatively shallow snow cover like most of the upper Midwest portion of the United States. For areas which generally have a deep snow cover a value of TIPM in the range of 0.1 to 0.2 would be appropriate. A value of TIPM between 0.2 and 0.5 would be reasonable in areas which usually have a moderate amount of snow like much of northern New England.

The steady state equation for heat transfer in a homogeneous snow cover can be expressed as:

$$Q = Ke * \frac{\Delta T}{\Delta z} \tag{2}$$

where Q is the heat transfer in Mme/6HR (MMe is the energy required to melt or freeze 1 MM of ice or water at zero DEGC and is approximately 8 CAL/CM2)

Ke is the the effective thermal conductivity of snow (MMe/DEGC/6HR)

$\Delta T/\Delta z$ is the temperature gradient - difference in temperature, ΔT, over difference in depth, Δz (DEGC/CM)

A comparison of this equation with Equation 22 in Chapter II.2-SNOW-17 [Hyperlink] indicates that the negative melt factor is equal to $Ke/\Delta z$. The value of Ke has been found experimentally to be mainly a function of the density of snow [Anderson (1976)]. Thus the negative melt factor is a function of snow density and Δz. Table 2 [Bookmark] shows calculated values of the negative melt factor for various values of density and Δz. The Δz values in Table 2 were selected to reasonably represent depths corresponding to ATI values computed using the recommended initial values of TIPM for shallow, medium and deep snow covers respectively. Since NMF is the maximum negative melt factor it should be based on the typical maximum snow density for the area. Maximum snow densities generally occur during the melt season and typically vary from about 0.3 for shallow snow to 0.5 for a very deep snow cover. This suggests that the underlined values in Table 2 would be good initial estimates of NMF. Since these values are all similar it suggests that a good default value for NMF is 0.15 MMe/DEGC/6HR. It should be remembered that in reality heat transfer in a snow cover is not a steady state process the snow surface temperature is usually not equal to the air temperature and the depth corresponding to the value of ATI undoubtedly varies with time. Thus the values given in Table 2 should only be used to suggest reasonable initial values and indicate something about the likely range in values for NMF.

Table 2. Computed negative melt factors for various values of snow density and Δz (units of MMe/DEGC/6HR)

density	Δz = 10 CM	Δz = 20 CM	Δz = 30 CM
0.3	.16	.08	.05
0.4	.27	.14	.09

0.5	.42	.21	.14

[Next] [Previous] [Bookmarks] [Top]

2. **MBASE** - A melt base temperature of zero DEGC has proven to be completely adequate in the vast majority of watersheds. An initial value of MBASE other than zero DEGC could be justified in the case of a heavily conifer-forested area. Since most climatological stations are located at relatively open sites the measured daytime temperature is generally warmer than the temperature beneath a dense forest canopy. The use of a value for MBASE of 0.5 to 1 DEGC is one way to compensate for this difference. Another way that is probably more realistic is to adjust the temperature data to reflected conditions under the forest canopy. This can be accomplished by using an artificial elevation difference and lapse rates which increase temperatures slightly at night and reduce temperatures to a greater extent during the day with a net effect of lowering the temperature by about 0.5 to 1 DEGC.

[Next] [Previous] [Bookmarks] [Top]

3. **PXTEMP** - Various studies have shown that the temperature at which precipitation is equally likely to be rain or snow typically is in the range of 0 to 2 DEGC. Thus a good default value for PXTEMP is 1 DEGC. In some cases the fixed diurnal variation in temperature used in the MAT procedure causes the MAT values to be in error during periods of changing weather. Precipitation is often associated with such periods. In most areas these errors in MAT values cause random errors in the form of precipitation and cannot be corrected by adjusting PXTEMP. However in some areas PXTEMP can be altered to compensate for errors in MAT values caused by using a fixed diurnal temperature pattern. For example in the sub-alpine and alpine regions of Colorado precipitation almost always occurs as snow even when the maximum temperature is as high as 3 to 5 DEGC.

[Next] [Previous] [Bookmarks] [Top]

4. **PLWHC** - The percent liquid water holding capacity for ripe snow has been found to be on the order of 2 to 5 percent. Thus the parameter PLWHC would be in the range of 0.02 to 0.05. PLWHC should be somewhat greater for fresh snow. However it is hard to determine the liquid water holding capacity of fresh snow because by the time drainage ceases the snow has become ripe. Thus the concept of liquid water holding capacity probably pertains only to ripe snow. Besides the liquid water retained in proximity to the snow crystals additional liquid water can be contained in capillary slush layers which form above ice layers or at the snow-soil interface. Thus PLWHC should be increased in areas where the snow cover typically contains slush layers during the melt season. In areas with shallow snow covers and flat slopes PLWHC can be as large as 0.2 to 0.3.

[Next] [Previous] [Bookmarks] [Top]

5. **DAYGM** - Ground melt occurs when the soil is not frozen. The amount of ground melt usually decreases throughout the snow season as the soil temperature drops. The parameter DAYGM is an average daily ground melt during a typical winter. Typical values for DAYGM vary from 0.0 MM for areas which typically have frozen ground to 0.3 MM for areas with relatively mild climates and yet deep snow covers like the Sierra Nevada. The value of DAYGM could

be greater than 0.3 MM in areas where snow cover is a rather infrequent occurrence.

The water generated by melt at the snow-soil interface increases tension water contents throughout the winter. As soil moisture increases some of this meltwater may replenish base flow storages. An increase in base flow due to ground melt can sometimes be observed by examining the daily flow hydrograph when the snow cover begins or when soil moisture conditions reach the point that melt-water is recharging the base flow storages. However it is difficult to determine the magnitude of the initial value of DAYGM from an analysis of the hydrograph.

[Next] [Previous] [Bookmarks] [Top]

References

Anderson, Eric A., 1976, A Point Energy and Mass Balance Model of a Snow Cover, NOAA Technical Report NWS 19, U.S. Dept. of Commerce, Silver Spring, MD.

Figure 1. Characteristic shapes of snow cover areal depletion curves

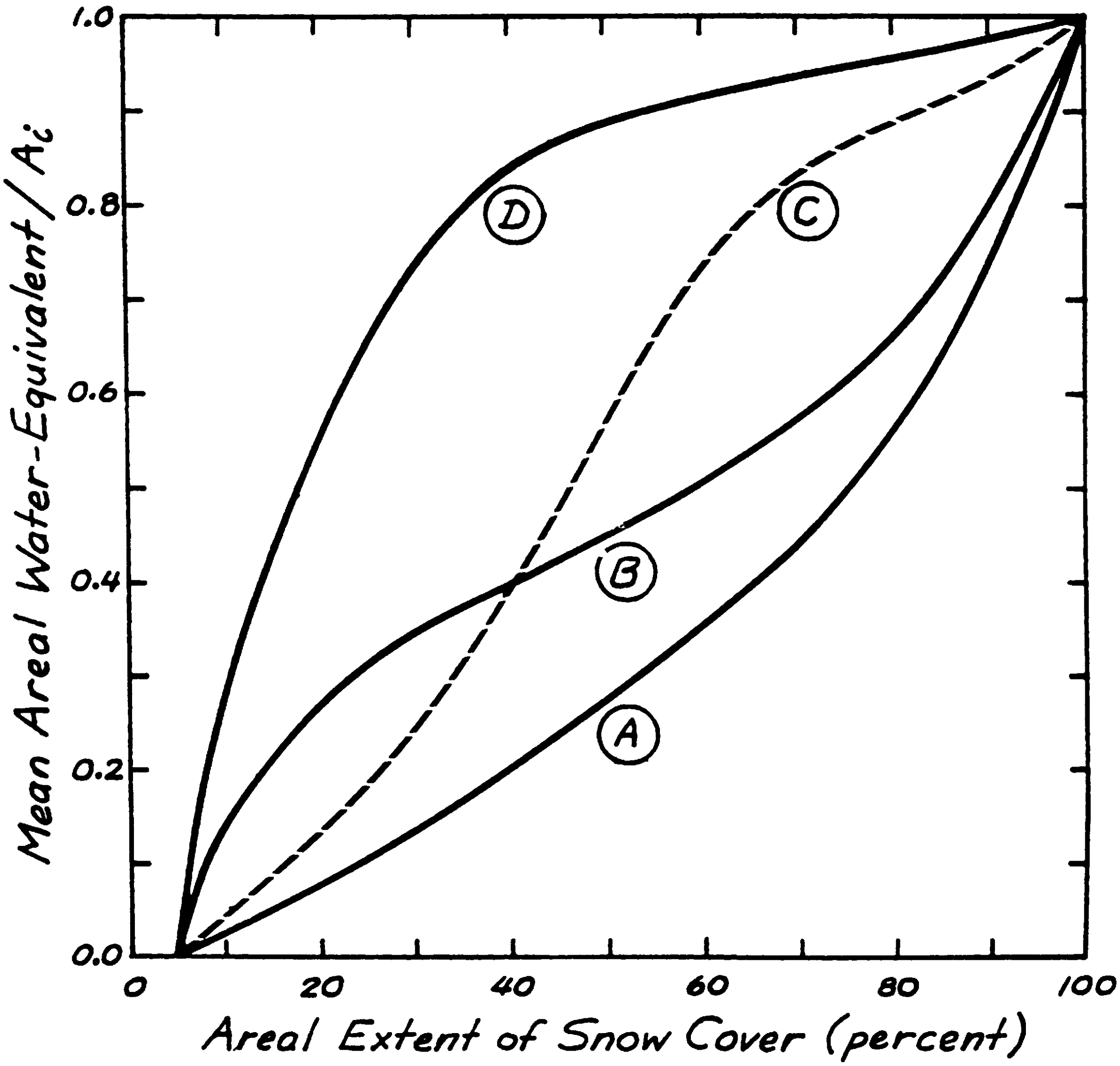

Figure 1. Characteristic shapes of snow cover areal depletion curves.

Index

[Top]