# SNOW-17 Model

## .1 Description of Algorithm

http://www.nws.noaa.gov/oh/hrl/nwsrfs/users_manual/part2/_pdf/22snow17.pdf

## .2 Model Parameters

SNOW-17 uses an xml representation of model parameters where each parameter is captured within a separate xml tag. The tags are closely related to the NWSRFS definition of SNOW-17 defined at:

http://www.nws.noaa.gov/oh/hrl/nwsrfs/users_manual/part5/_pdf/533snow17.pdf.

The table below shows the available parameter tags. For the parameters with type of string, the values are case-insensitive. For example, "YES" and "Yes" are treated by the program as the same value, but "Y" will be treated as error. The sequence of parameters in the table below or in the xml file has no any significance.

| Name | Type | Required [Yes/No] | Comment |
|---|---|---|---|
| PERCENT_ SNOWFALL_ INPUT_OPTION | String | No | o Only two possibilities: "Yes" or "No". Default value is "No"; <br> o If set to "Yes", use the input percent-snow-fall time series, required to be present; <br> o If absent or set to "No", don't use the input percent-snow-fall time series, regardless if the time series is present or not <br> o Needs to be refactored to use boolean value |
| RAIN_SNOW_ELEV_ INPUT_OPTION | string | No | o Only two possibilities: "Yes" or "No". Default value is "No"; <br> o If set to "Yes", use the input rain-snow-elevation time series (RSEL), which is required to be present. The parameter AREA_ELEV_CURVE is required to be present too. <br> o If absent or set to "No", don't use the input rain-snow-elevation time series, regardless the time series is present or not. <br> o Needs to be refactored to use Boolean value |

| Name | Type | Required [Yes/No] | Comment |
|---|---|---|---|
| ALAT | double | Yes | o Latitude of the area;<br>o If $\geq 54.0$, use Alaskan seasonal melt-factor variation |
| PXADJ | double | Yes | o Must be between 0.0 and 1.0;<br>o Unitless |
| ELEV | double | Yes | o Elevation of the area(Units of M) |
| TAELEV | double | No | o Elevation associated with the air temperature time series(M);<br>o Default value is same as ELEV<br>o When TAELEV $\neq$ ELEV, air temperature will be adjusted by using lapse rate, which is related to the local time zone. |
| TALMAX or TALMIN | double | No; Required when TAELEV $\neq$ ELEV | o Lapse rate at time of maximum/minimum temperature;<br>o Units of DEGC/100M |
| AREA_ELEV_CURVE (METR) Or AREA_ELEV_CURVE (ENGL) | table | No; Required when RAIN_ SNOW_ ELEV_ INPUT_ OPTION is "Yes" | o A series pairs of numbers(double values);<br>o 1$^{st}$ number in the pair is elevation of the area(units of M or FT, corresponding to METR or ENGL);<br>o 2$^{nd}$ number of a pair is the decimal fraction of area below the elevation;<br>o 1$^{st}$ number of 1$^{st}$ pair is minimum elevation, the decimal fraction is fixed to be 0.0;<br>o 1$^{st}$ number of last pair is maximum elevation, the decimal fraction is fixed to be 1.0 |
| AREA_DEPLETION_ CURVE | table | Yes | o Areal snow cover at WE/Ai ratios of 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1.0; Total 11 numbers.<br>o Decimal fraction. |

| Name | Type | Required [Yes/No] | Comment |
|---|---|---|---|
| SWE_OUTPUT_TS_ INTERVAL Or SASC_OUTPUT_TS_ INTERVAL Or SNSG_OUTPUT_TS_ INTERVAL | integer | No | o The output time series interval. Default value is input air temperature time series interval; o If present, must be an even multiple of air temperature time series interval |
| SCF | double | Yes | o Snowfall correction factor |
| MFMAX Or MFMIN | double | Yes | o Maximum/minimum non-rain melt factor; o Units of MM/DEGC/6HR |
| UADJ | double | Yes | o Average value of the wind function during rain-on-snow events o Units of MM/MB |
| SI | double | Yes | o Areal water-equivalent above which there is always 100% |
| MV | integer | Yes | o Flag to indicate seasonal melt-factor variation. Only 2 choices: 0 or 1. o 0: use normal SMFV, based on latitude o 1: use specified SMFV o Needs to be refactored to use string value: "normal" or "specified" |
| SMFV | table | No; Required when MV is 1 | o User specified seasonal melt-factor variation; o 12 values: the decimal fraction of where the melt-factor is between MFMIN and MFMAX on the 16th of each month |
| NMF | double | Yes | o Maximum negative melt factor; o Units of MM/DEGC/6HR |
| TIPM | double | Yes | o Antecedent snow temperature index parameter; o Range is 0.1 to 1.0 |
| MBASE | double | Yes | o Base temperature for non-rain melt factor; o Units of DEGC |

| Name | Type | Required [Yes/No] | Comment |
|------|------|-------------------|---------|
| PXTEMP | double | Yes | o Temperature that separates rain from snow;<br>o Units of DEGC |
| PLWHC | double | Yes | o Maximum amount of liquid water held against gravity drainage-decimal fraction |
| DAYGM | double | Yes | o Daily melt at the snow-soil interface<br>o Units of MM |
| WETOL[0., 1.0]<br>Or<br>SCTOL[0., 1.0] | double | Yes | o Tolerance used when updating water-equivalent or areal extent of snow cover with observed data;<br>o Range is 0.0 to 1.0;<br>o Updates when \|Simulated-Observed\| > tolerance * Observed |

## .3    Model States

Like all the other models, SNOW-17 model states are also defined in a property file format. An example is shown below. The sequence of property names in the state file or in the table below has no any significance. The model state property names are:

| Property Name | Description |
|---------------|-------------|
| ACCMAX | Maximum water-equivalent that has occurred since snow began to accumulate (units of MM) |
| AEADJ | Areal extent of snow cover adjustment; units of MM |
| EXLAG_ARRAY | Lagged excess water (units of MM); number of values is 5/timeint +2 where timeint is the precipitation time series interval (MAP_INTERVAL) |
| LIQW | Initial amount of liquid-water held against gravity drainage (units of MM) |
| NEGHS | Initial heat deficit (units of MM) |
| SB | Areal water equivalent just prior to the new snowfall(units of MM) |
| SBAESC | Areal extent of snow cover just prior to the new Snowfall (units of PCT) |
| SBWS | Water equivalent above which 100 percent areal snow cover temporarily exists (units of MM) |
| SNDPT | Snow depth; units of  CM, however, the snow depth output time series is in unit of MM, because FEWS expects it in MM. |
| SNTMP | Average snow cover temperature (units of DEGC) |
| STORGE | Excess liquid water in storage (units of MM) |
| TAPREV | Previous air temperature (units of DEGC) |

| Property Name | Description |
|---|---|
| TINDEX | Initial antecedent snow temperature index (units of DEGC) |
| WE | Initial water equivalent of solid (ice) portion of the snow cover (units of MM) |
| UNIT | This entry is optional. The presence of "UNIT=METRIC" in state file is only for visual information, because the state is always in METRIC units, never in ENGLISH units; an exception will be thrown if "UNIT=ENGLISH" is present in the state file. |
| MAP_INTERVAL | This entry is optional and for carryover transfer. It is the precipitation time series interval when this state was calculated, units of HR. It is used to compare with the current precipitation time series interval. If different, the carryover transfer is invoked. The default value is 6. |

A sample state file:

```
ACCMAX=180.0
AEADJ=0.0
EXLAG_ARRAY=0.0 0.0
LIQW=7.0
NEGHS=0.6
SB=181.0
SBAESC=1.0
SBWS=180.0
SNDPT=78.0
SNTMP=-2.8
STORGE=0.0
TAPREV=-99.0
TINDEX=-3.0
WE=173.0
UNIT=METRIC
MAP_INTERVAL=6
```

## .4    Model Time Series

SNOW-17 has 2 required input time series and 5 optional input time series. The units of the input time series are very flexible. If it is length unit, like MAP time series, it can be any length unit (CM, M etc). If it is temperature unit, like MAT time series, it can be DEGC or DEGF. The program will internally convert the input time series to expected units. The "Units" column in the table below, for the input time series, indicates the internal Model Units; for the output time series, indicates the output time series units.

INPUT TIME SERIES:

| Time Series Type | Units | Time Series Interval(HR) | Missing Values Allowed | Required [Yes or No] |
|---|---|---|---|---|
| MAP | MM | Any | No | Yes |
| MAT | DEGC | Any 1/ | No | Yes |
| PTPS | PCTD | Any 2/ | Yes | No |
| RSEL | M | Any 3/ | No | No |
| SNWE | MM | Any 4/ | Yes | No |
| AESC | PCTD | Any 4/ | Yes | No |
| SNOG | CM | Any 4/ | No | No |

OUTPUT TIME SERIES:

| Time Series Type | Units | Time Series Interval (HR) | Missing Values Allowed | Description |
|---|---|---|---|---|
| Primary Time Series 5/: | | | | |
| RAIM | MM | Any 2/ | No | rain plus melt |
| SASC | PCTD | Any 4/ | No | snow covered area percentage |
| Secondary Time Series 5/: | | | | |
| SWE | MM | Any 4/ | No | Snow water equivalent |
| SNSG | MM | Any 4/ | No | Snow depth |
| PRAIN | MM | Any 3/ | No | Precip as rain |
| PSFALL | MM | Any 3/ | No | Precip as snow fall |
| PROBG | MM | Any 3/ | No | Rain on bare ground within MAT interval |
| PSNWRO | MM | Any 3/ | No | Snow pack outflow within MAT interval (note: the sum of PROBG and PSNWRO equals to RAIM) |
| ACCMAX | MM | Any 2/ | Yes | Maximum water-equivalent that has occurred since snow began to accumulate (units of MM) |
| AEADJ | MM | Any 2/ | Yes | Areal extent of snow cover adjustment; units of MM |
| LIQW | MM | Any 2/ | Yes | Initial amount of liquid-water held against gravity drainage (units of MM) |
| NEGHS | MM | Any 2/ | Yes | Initial heat deficit (units of MM) |
| PQNET | MM | Any 2/ | Yes | state |
| SB | MM | Any 2/ | Yes | Areal water equivalent just prior to the new snowfall (units of MM) |
| SBAESC | PCTD | Any 2/ | Yes | Areal extent of snow cover just prior to the new Snowfall (units of PCT) |
| SBWS | MM | Any 2/ | Yes | Water equivalent above which 100 percent areal snow cover temporarily exists (units of MM) |
| SNDPT | MM | Any 2/ | No | Snow depth; in unit of MM |
| SNTMP | DEGC | Any 2/ | Yes | Average snow cover temperature (units of DEGC) |
| STORGE | MM | Any 2/ | Yes | Excess liquid water in storage (units of MM) |

| | | | | |
|---|---|---|---|---|
| TAPREV | DEGC | Any 2/ | Yes | Previous air temperature (units of DEGC) |
| TINDEX | DEGC | Any 2/ | Yes | Initial antecedent snow temperature index (units of DEGC) |
| WE | MM | Any 2/ | Yes | Initial water equivalent of solid (ice) portion of the snow cover (units of MM) |

Notes:
1/: Must be even multiple of the MAP interval;
2/: Must be the same as the MAP interval;
3/: Must be the same as the MAT interval;
4/: Must be even multiple of the MAT interval. For the output time series, if its interval not specified in the parameter xml file, the default value is the MAT interval.
5/: There are two versions for the model to run, a "slim version" and a "full version". The version is determined by the technique "SACSNOW" (default value is false). When SACSNOW is true, the model runs the "full version" and when it is absent or false, the "slim version" is executed. This technique is used by both SNOW-17 and the SAC-SMA model. The slim version is much faster than the full version, because it only produces the three primary output time series (RAIM, SASC and SWE). The rest of the time series are the secondary output and are only generated when running in "full version".

## .5 Modifications (Mods)

The SNOW-17 model has six mods it accounts for. The units are for the internal model units.

| Parameter Id | Units | Time Step | Description |
|---|---|---|---|
| AESCCHNG 4/ | PCTD | Any 2/ | Sets the value of the areal extent of snow cover for the date specified. The technique UPSC can turn it off. |
| MFC 3/ | REAL | Any 1/ | Sets the melt correction factor for the date specified. |
| RAINSNOW 3/ | INT | Any 1/ | Sets the precipitation at this time step as rain or snow, so it is not determined by the temperature index. The value of "1.0" set the precipitation at this time step as rain, "2.0" as snow, anything else (including "0.0", "-999.0") is no RAINSNOW MOD. |
| UADJ 3/ | REAL | Any 1/ | Multiplies the average wind function adjustment (UADJ) |

| | | | parameter. |
|---|---|---|---|
| WEADD 4/ | MM | Any 2/ | Sets the value to add to the snow water equivalent for the date specified. |
| WECHNG 4/ | MM | Any 2/ | Sets the value for the snow water equivalent for the date specified. The technique UPWE can turn it off. |

Notes:

1/: a non-equidistant time series: There is no time step interval. The time step events do not need to be continuously present from the start date to the end date. Its xml file header contains the following: <timeStep unit="nonequidistant"/>

2/: an equidistant time series: the time step interval is fixed and all the time steps must be present from the start date to the end date. Its xml file header contains the following (e.g. 6 hour time interval): <timeStep unit="hour" multiplier="6"/>

3/: the mods are independent on the last observation date (the time to switch from the observed time to the forecast time).

4/: the mods that are after the last observation time are ignored. Only the mods before or equal to the last observation time are used.

## .6 Notes about configuring Model in FEWS workflow

Time Zone
The time zone information specified in run_info.xml is critical to the model in some circumstances. When TAELEV ≠ ELEV, the input air temperature will be adjusted by using the lapse rate, which depends on the local time zone. Therefore, we recommend always specifying the local time zone in run_info.xml, and not using the GMT time zone. The output time series always uses the same time zone as run_info.xml.

Run Time Options (known as TECHNIQUES in NWSRFS).
SNOW-17 allows six run-time options. When specified they should appear in the run_info.xml file.

Example run info using SACSMA run time options
<properties>
      <int key="printDebugInfo" value="0"/>
      <string key="rootDir" value="Modules/sacsma/amen8/"/>
      <string key="model"
value="ohd.hseb.ohdmodels.sacsma.Snow17ModellDriver"/>
      **<string key="PRINTSNW" value="TRUE"/>**
      **<string key="SACSNOW" value="TRUE"/>**
      **<string key="SNOW" value="TRUE"/>**
      **<string key="UPSC" value="FALSE"/>**
      **<string key="UPSNW" value="FALSE"/>**
      **<string key="PRECIP_IS_ALL_RAIN" value="TRUE"/>**
   </properties>

1. PRINTSNW – produces detailed daily information in the form of a text based table. One example is shown below. The default value is "FALSE". The similar technique used in SAC-SMA model is "PRINTSMA".

```
SNOW-17 completion testing -------Basin: forecast_wtlo3u
'WTLO3XU' DAILY OUTPUT IS FOR HOUR 12    TIME ZONE=Z
DAY SNOWFALL[MM] RAIN_ON_SNOW[MM] ENERGY_EXCHANGE[MM] SIM.COVER PCT.LIQ.WATER HEAT_DEFICIT[MM] SNOW_TEMP.[C] SIM.DEPTH[CM] OBS.DEPTH[CM] SIM.WE[MM] OBS.WE[MM] OBS.COVER RAIN-SNOW-ELEVATION[M]
14  3.1      0.0         -0.1        1.0     0.0       0.9        -4.3      20.4    -999.0    26.0   -999.0   -999.0    196.0
15  1.1      0.0         -0.5        1.0     0.0       1.5        -6.8      19.5    -999.0    27.0   -999.0   -999.0    -60.0
16  0.0      0.0         -0.5        0.99    0.0       2.0        -7.3      17.8    -999.0    27.0   -999.0   -999.0
17  0.0      0.0          0.0        0.98    0.0       2.0        -6.2      16.4    -999.0    27.0   -999.0   -999.0
18  8.2      0.0          0.4        1.0     0.0       1.6        -3.5      22.1    -999.0    35.0   -999.0   -999.0    146.0
19  24.5     0.0         -0.8        1.0     0.0       2.5        -4.2      39.8    -999.0    59.0   -999.0   -999.0     53.0
20  13.7     0.0         -0.6        1.0     0.0       3.1        -4.6      47.9    -999.0    73.0   -999.0   -999.0    -86.0
21  25.2     0.0         -0.5        1.0     0.0       3.6        -4.2      63.2    -999.0    98.0   -999.0   -999.0    294.0
22  19.2     0.0         -0.3        1.0     0.0       3.8        -3.8      68.8    -999.0   117.0   -999.0   -999.0    511.0
```

2. SACSNOW – This technique is used by both SNOW-17 and SAC-SMA model. It determines running the model in "slim version" or "full version". See the notes about the output time series above. The default value is "FALSE" (slim version).
3. SNOW – controls whether the snowmelt algorithm should be used. Note: when setting to "FALSE", the model computation is skipped. There are only primary output time series generated. The output time series, RAIM, has the same value as the input MAP time series. The other output time series, SASC, and all output states, have the value of "0.0". The default value is "TRUE" (doing the model computation).
4. UPSC and UPWE – controls whether AESCCHNG and WECHNG mods are allowed to be used. The default value is "TRUE".
5. PRECIP_IS_ALL_RAIN – default value is "FALSE". When the value is "TRUE", the precipitation is forced to be as 100% rain, regardless of the air temperature. When the property is absent or "FALSE", no such forcing will be enforced. (Note: this feature is similar to RAINSNOW MOD to some extent. However, RAINSNOW MOD is an input time series which dictates the precipitation being rain or snow at each time step. This property, if present and with value of "TRUE", forces the precipitation to be rain at all the time steps.)

Examples:
Module Configuration File
ModuleConfigFiles\SNOW17_HCRK1_HCRK1_Forecast.xml
Module Parameter File
ModuleParFiles\SNOW17_HCRK1_HCRK1_UpdateStates.xml

## .7    FEWS Adapter Used

The SNOW-17 model uses the OHDFewsadapter to communicate. Information about this adapter can be found at OHDFewsadapter.