# Long Term Simulations

# Features

- Unlimited simulation time
- Unlimited number of storm events
- Evapo-transpiration
  - Seasonal parameters
- Soil moisture accounting

# Global Parameters

- For radiation calculations
  - Latitude
  - Longitude
  - GMT offset
- Minimum event discharge
  - Controls event reporting
- Soil moisture depth
  - Uniform for GAR calculations unless coupled with groundwater
  - Equal to second layer depth for MLGA
  - Maximum for RE calculations

# Infiltration Models

- Green and Ampt with Redistribution (GAR)
- Multilayer Green and Ampt Model (MLGA)
- Richards' equation

# GAR Model

- Green and Ampt model with multiple wetting fronts
- Soil pore water is redistributed during rainfall hiatus
- Allows infiltration capacity to recover during periods of no, or low, rainfall intensity

# MLGA Model

- Three layer G&A model
- Different soil columns may be applied to different overland flow cells
  - Index map
  - Table of properties

# Parameters for Green and Ampt Based Infiltration Models

- Saturated hydraulic conductivity
- Wetting front suction head
- Porosity
- Pore distribution index
  - straight line/pore water flow length
- Residual saturation
  - saturation of air dry soil
- Field capacity
  - saturation level when free drainage stops
- Wilting point water content
  - soil moisture below which plants cannot transpire
  - plant die
  - ET ceases
- Initial moisture content

# Assignment of Parameters

- Based on index map of land use and soil texture
- Initial values assigned based on Rawls et al. (1982)
- GAR
  - With index map and mapping tables
  - Supported by WMS
- MLGA
  - With index map and mapping tables
  - Supported by WMS

# Richards' Equation

- Numerical solution of discretized soil column.
- User specifies node spacing in three layer system
- Parameters assigned with index map and mapping table
- Supported by WMS

# Evapo-transpiration

- Hourly computation of potential evapotranspiration (PET) due to meteorological factors
- Penman-monteith for vegetated areas
- Deardorff for bare soils
- PET sent as demand to soil moisture accounting method
- AET determined from soil moisture, and properties, in each soil column

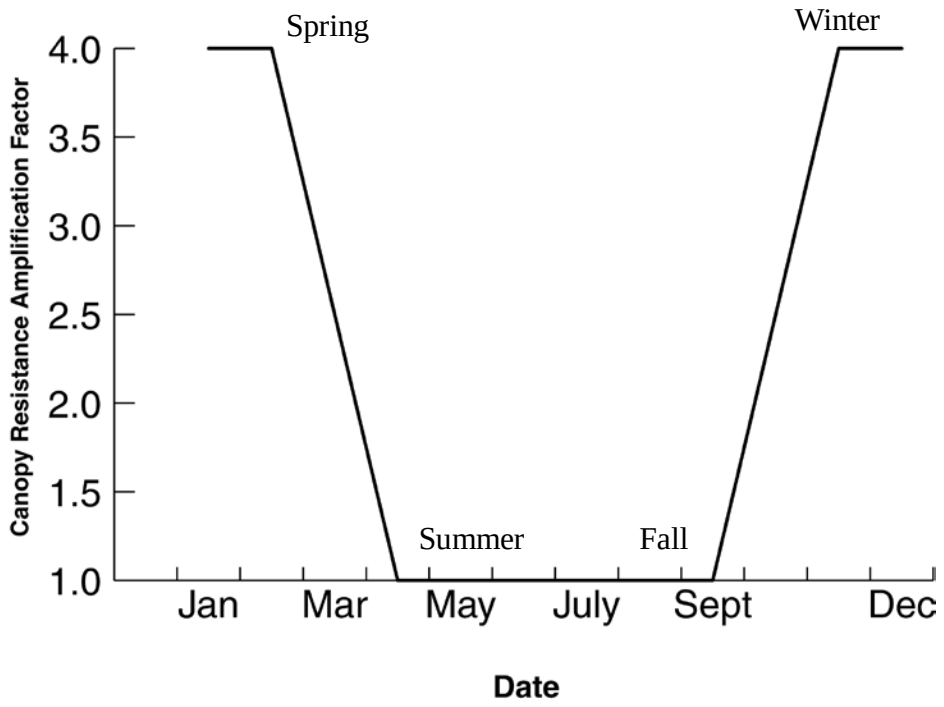
# Distributed Evapo-transpiration Parameters

- Land surface albedo
- Vegetation height (m)
  - when using Richards' equation the root depth in each cell is set equal to the vegetation height, unless it exceeds the global value of root depth
- Vegetation transmission coefficient - fraction of direct solar radiation penetrating the vegetation canopy and reaching the ground
- Canopy stomatal resistance - resistance of the canopy to transpiration at noon (s/m)

# Assignment of Parameters

- Index map and mapping tables
- Index map of land use or vegetation type
- Tables/charts of values found in GSSHA User's Manual on the gssha wiki

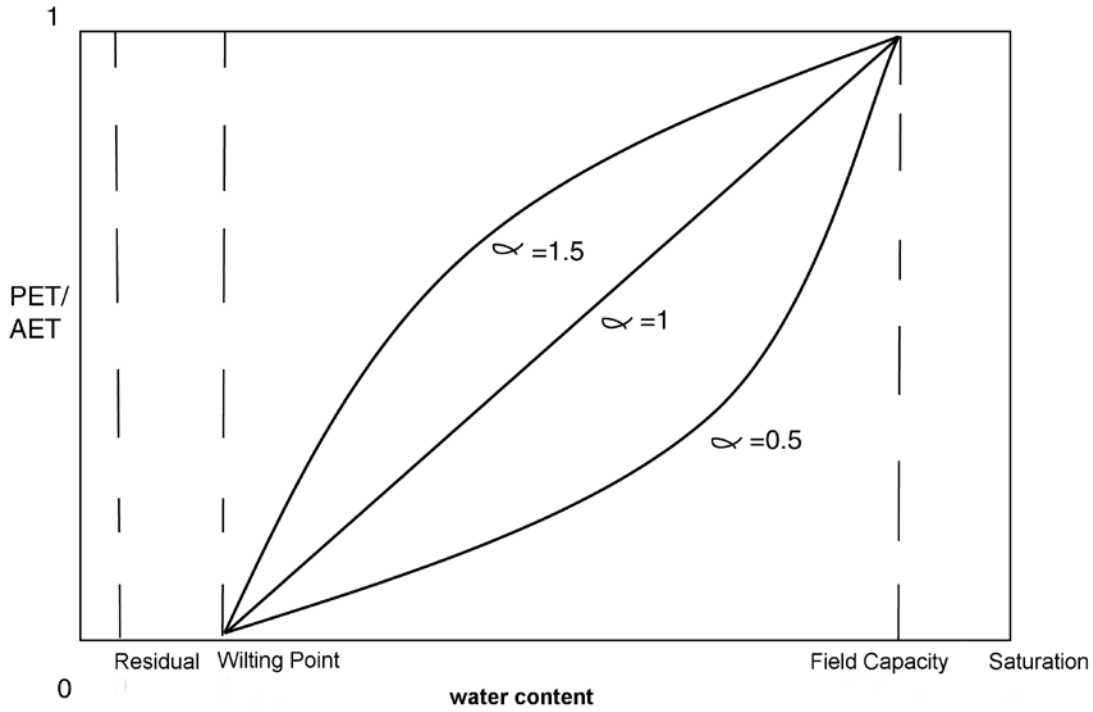
# Seasonal Canopy Resistance




- Canopy resistance controls ET in the Penman Monteith Eq.
- Canopy resistance is the inverse of Leaf Area Index (LAI)
- Input values are peak summer growing period
- An option allows the canopy resistance to vary seasonally
- The inflection points – spring, summer, fall, winter, may be specified in GSSHA
- Same inflections points are used for rainfall interception.

# Evapotranspiration

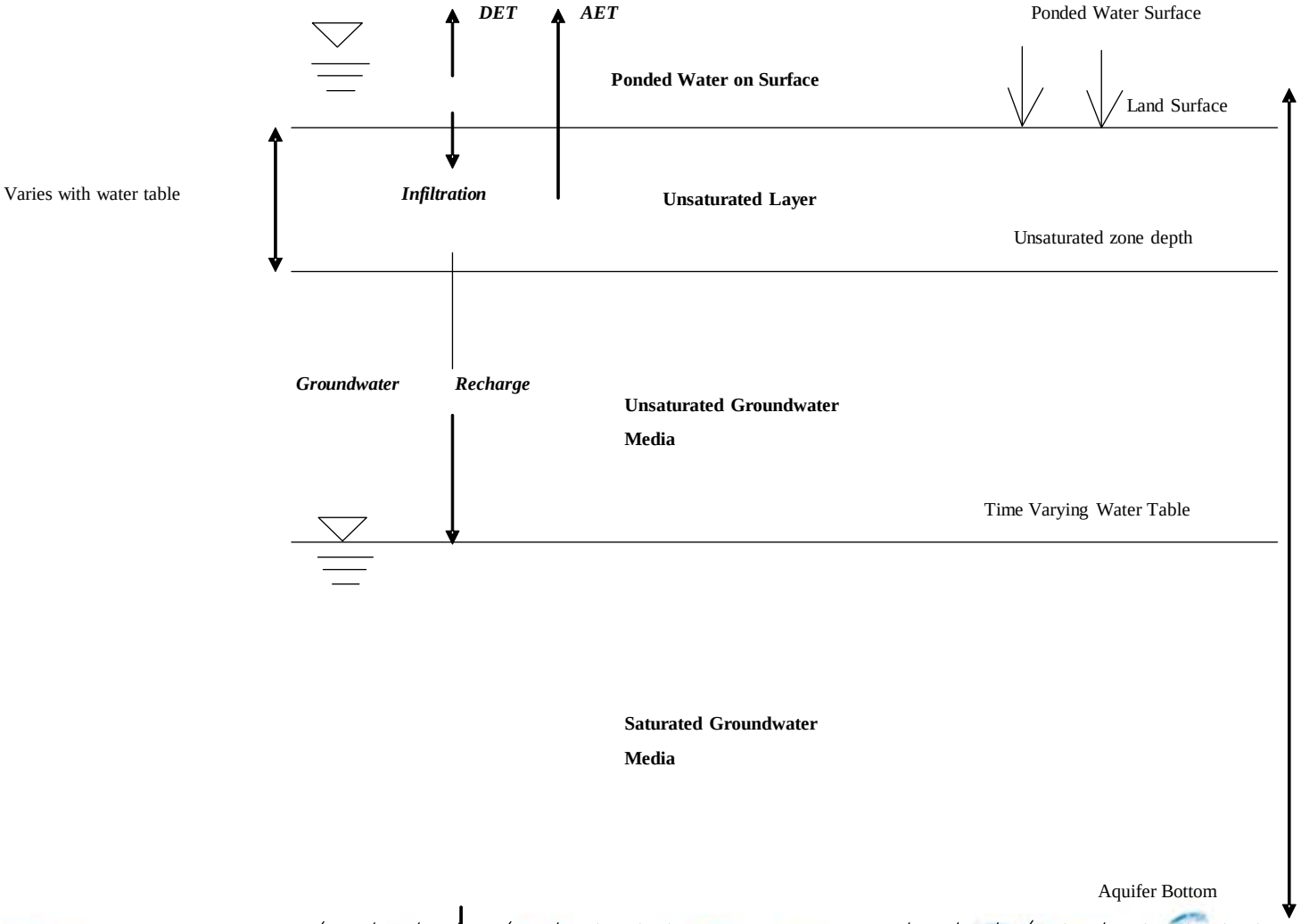
- AET calculated based on the soil moisture of each layer within the root depth



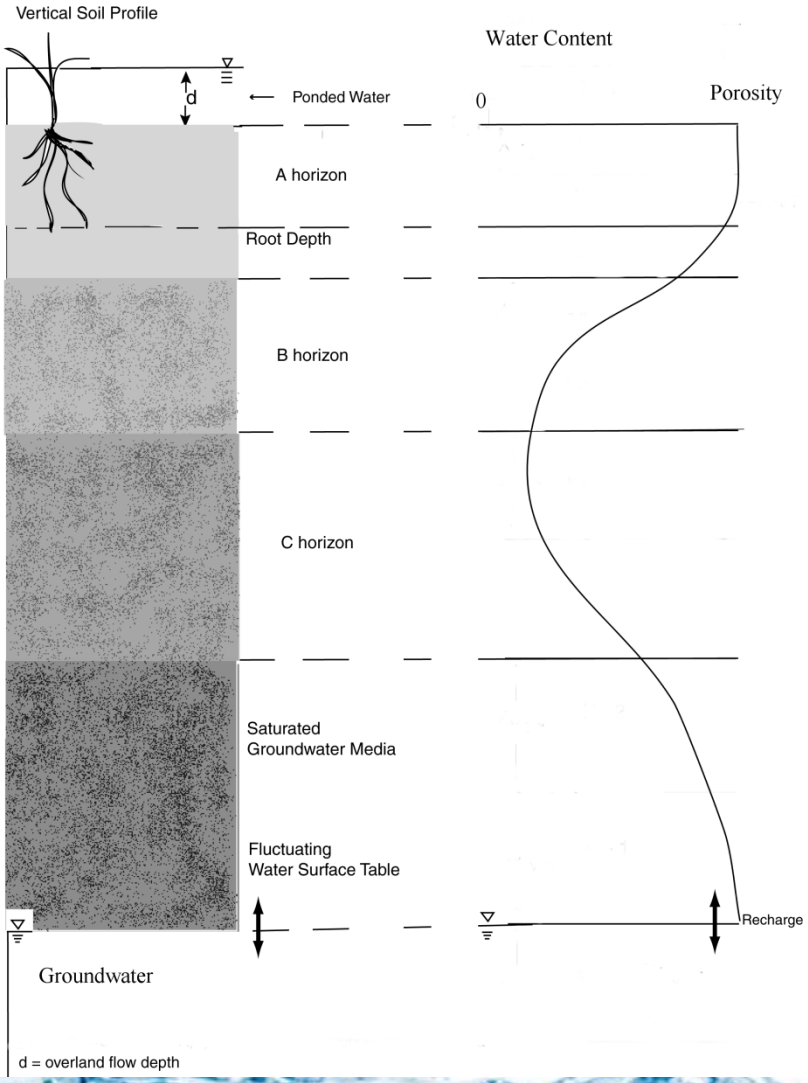
# Soil Moisture Accounting

- GAR and MLGA - two layer model
- RE - number of layers user defined
- Solved hourly unless infiltration occurs
- Solution includes
  - Infiltration
  - AET
  - Movement between layers
    - GAR and MLGA – drainage
    - RE - drainage and capillary movement in both directions depending on conditions

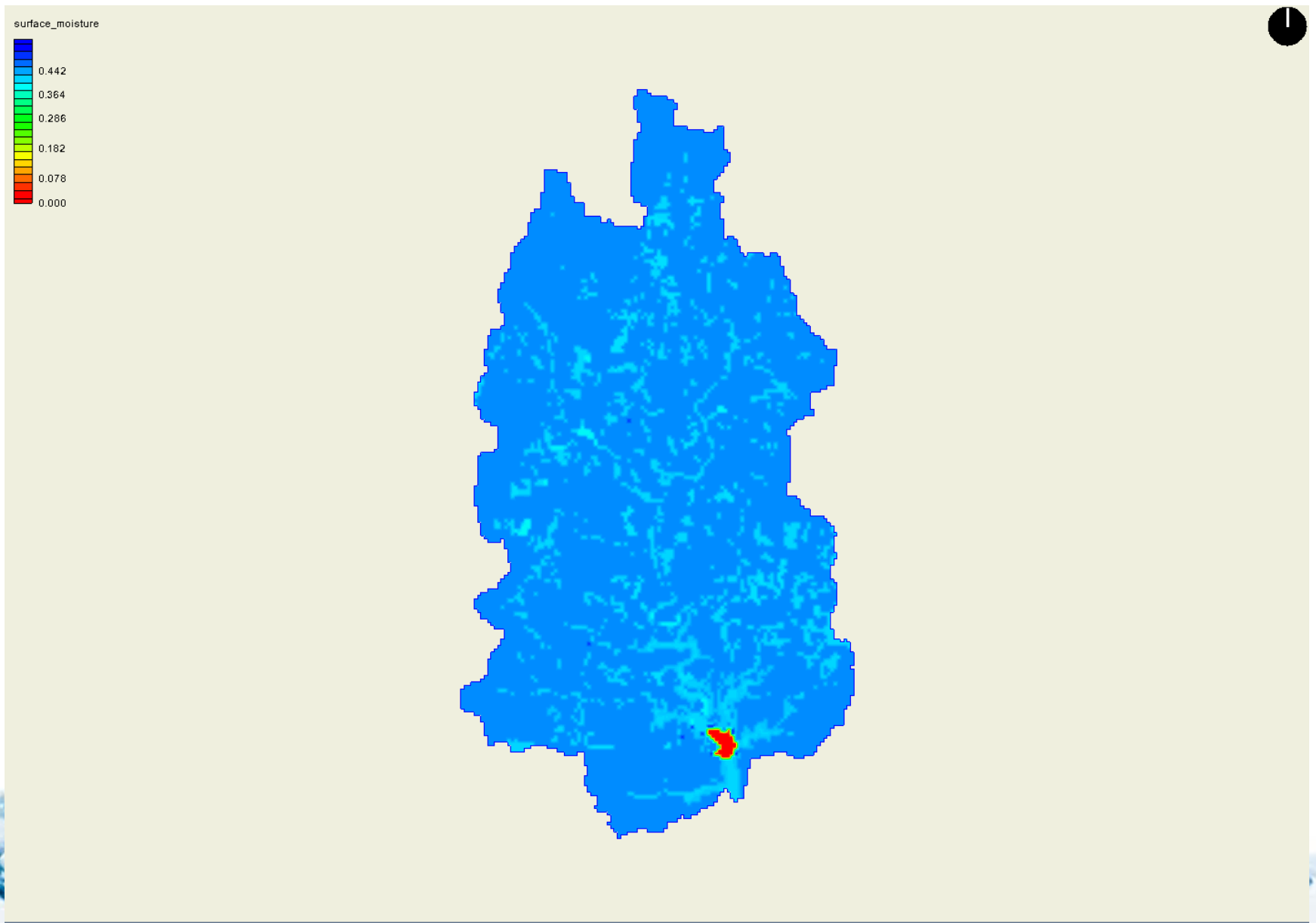
# Simple Soil Moisture Accounting



# Richards' Equation

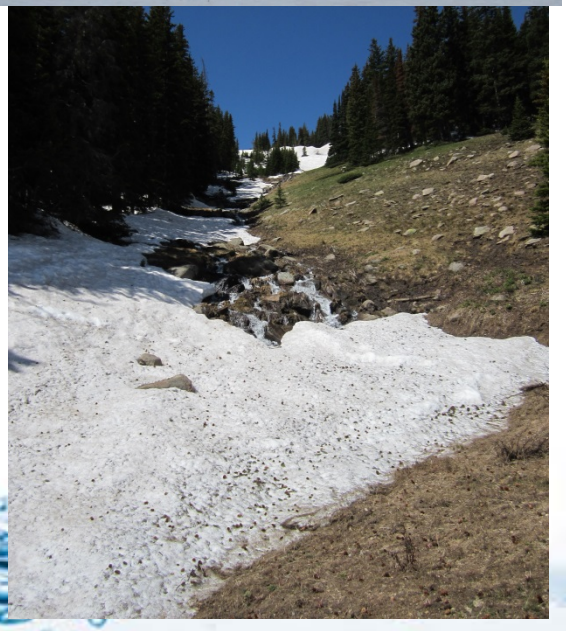


# Soil Moisture Evolution



# Overview

- Modeling of Snow Water Equivalent (SWE)
  - Three Snow Accumulation / Melt Methods
    - Energy Balance Method
    - Temperature-Index Method
    - Hybrid Energy Balance Method
  - Accounting for the Snow Pack Dynamics within the Snow Pack
- Adjustments to HMET Forcing Data
- Melt Water Transport
  - Vertical Flow through Snow Pack
  - Lateral Flow through Snow Pack
  - Frozen Ground to Impede Infiltration
- Examples and Options



# Hydrometeorlogical (HMET) Inputs

- Hourly values of
  - Barometric pressure (in Hg)
  - Relative humidity (%)
  - Total sky Cover (%)
  - Wind speed (kts)
  - Dry bulb temperature (F)
  - Direct radiation ($Wh/m^2$)
  - Global radiation ($Wh/m^2$)

# HMET Data Sources

- National Climatic Data Center (NCDC)
  - historical data
    - SAMPSON CD
    - 1961-1990
  - recent data
    - TD 3280 - surface airways data
    - TD 3281 - surface airways and radiation data
- Commercial vendors
  - Earth info, etc.

# HMET FORMATS

- SAMPSON - for SAMPSON CD data
- Surface Airways - for TD3280 and TD3281 formatted data
- WES - concise tabular format of required variables only

# WES HMET FORMAT

| Col. | Variable | Units | No Data Flags | Type |
|---|---|---|---|---|
| 1 | Year (4 digit) | | | integer |
| 2 | Month | | | integer |
| 3 | Day | | | integer |
| 4 | Hour | | | integer |
| 5 | Barometric Pressure | in Hg | No Data (ND) = 99.999 | real |
| 6 | Relative Humidity | % | ND=999 | integer |
| 7 | Total Sky Cover | % | ND=999 | integer |
| 8 | Wind Speed | kts | ND=999 | integer |
| 9 | Dry Bulb Temperature | $^{o}F$ | ND=999 | integer |
| 10 | Direct Radiation | W h $m^{-2}$ | ND=9999.99 | real |
| 11 | Global Radiation | W h $m^{-2}$ | ND=9999.99 | real |

# Missing Data

- Must enter no data codes for missing data
- Must have 1 line for each hour during simulation
  - Even if there is no data at all
  - Enter a line of ND codes
- GSSHA fills in ND codes

# EXAMPLE WES HMET

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2007 | 10 | 2 | 7 | 29.06 | 83 | 50 | 4 | 72 | 22.00 | 72.90 |
| 2007 | 10 | 2 | 8 | 29.09 | 78 | 88 | 4 | 73 | 78.00 | 239.70 |
| 2007 | 10 | 2 | 9 | 29.09 | 64 | 50 | 10 | 77 | 340.10 | 511.00 |
| 2007 | 10 | 2 | 10 | 29.09 | 65 | 25 | 12 | 79 | 606.20 | 751.20 |
| 2007 | 10 | 2 | 11 | 99.99 | 999 | 999 | 999 | 999 | 9999.99 | 9999.99 |
| 2007 | 10 | 2 | 12 | 29.07 | 65 | 50 | 14 | 79 | 677.30 | 889.50 |
| 2007 | 10 | 2 | 13 | 29.06 | 69 | 88 | 5 | 77 | 396.20 | 743.80 |
| 2007 | 10 | 2 | 14 | 29.04 | 69 | 88 | 9 | 77 | 353.20 | 679.90 |
| 2007 | 10 | 2 | 14 | 29.05 | 69 | 88 | 9 | 77 | 353.20 | 679.90 |
| 2007 | 10 | 2 | 15 | 29.04 | 69 | 100 | 10 | 77 | 0.00 | 292.50 |
| 2007 | 10 | 2 | 16 | 29.03 | 57 | 88 | 13 | 81 | 158.90 | 381.00 |
| 2007 | 10 | 2 | 17 | 29.04 | 64 | 88 | 14 | 77 | 50.60 | 183.80 |
| 2007 | 10 | 2 | 18 | 29.05 | 64 | 88 | 11 | 77 | 1.00 | 26.20 |
| 2007 | 10 | 2 | 19 | 29.07 | 78 | 100 | 3 | 73 | 9999.99 | 9999.99 |
| 2007 | 10 | 2 | 20 | 29.09 | 78 | 88 | 0 | 73 | 9999.99 | 9999.99 |

# GSSHA Fills in Missing Data

- Last recorded reading
  - total sky cover
  - wind speed
  - barometric pressure
- Same time from last recorded day
  - dry bulb temperature
  - relative humidity
  - direct radiation
  - global radiation
- Calculated from position, day of year, and time of day
  - long periods of missing radiation data

# Rain Gage File

- Series of spatially and temporally varied rainfall events
- No limit on number of events
- Type and number of gages can change between events but not during events

# Example Long Term Precipitation File

```
EVENT "Event of 30 June 1995- rainfall stops on July 1st"
NRGAG      3
NRPDS      5
COORD      205150.0   4750212.0 "center of radar pixel #1"
COORD      205045.0   4750104.0 "center of radar pixel #2"
COORD      205320.0   4751173.0 "center of radar pixel #3"
RADAR 1995 06  20  22  56              0.00        0.00        0.00
RADAR 1995 06  20  23  18             10.75        2.25        5.80
RADAR 1995 06  20  23  39             21.16        1.80       41.50
RADAR 1995 06  20  23  57             12.13       20.90       20.70
RADAR 1995 07  01  00  09             11.71       16.50        2.30
EVENT   "Event of 4 July 1995- new raingage network data"
NRGAG      4
NRPDS      7
COORD      204555.0   4751268.0      "location of raingage #1"
COORD      205642.0   4750491.0      "location of raingage #2"
COORD      205921.0   4750330.0      "location of raingage #3"
COORD      206170.0   4749611.0      "location of raingage #4"
GAGES 1995 07  04  09  47              0.0         0.0         0.0         0.0
GAGES 1995 07  04  10  01             38.0         2.0         0.0         0.0
GAGES 1995 07  04  10  16             16.0        14.0         3.0         0.0
GAGES 1995 07  04  10  35             19.0        20.0        16.0         8.0
GAGES 1995 07  04  10  49             14.0         0.0        26.0        16.0
GAGES 1995 07  04  11  01   8.0       42.0        21.0        22.0
GAGES 1995 07  04  11  13   0.0       19.0         9.0         9.0
```