

SnowDepth

User Guide

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1 Introduction

The SnowDepth™ software, which is based on the SNOW-17 theory, is a snow accumulation and ablation model used to estimate the depth of snow on natural surfaces. It is a conceptual model in which each of the significant physical processes affecting snow accumulation and snowmelt are mathematically represented. The model uses air temperature as the sole index to energy exchange across the snow-air interface and was developed to run in conjunction with a rainfall-runoff model.

A novel approach implemented in this software is the use of constrained non-linear least-squares optimization to calibrate model parameters for a particular location. This greatly enhances its accuracy in comparison to the standard SNOW-17.

Please refer to the instructions below in conjunction with the screenshots on the following pages.

1.1 Snow Depth Prediction Instructions

In order to make a prediction in the Current Simulation Panel based on Daily Precipitation [mm] and Average Ambient Data [°C]:

1. Press ‘Data File...’ in Current Simulation Panel and select relevant a ‘.csv’ Measurement file. The selected file name and directory will be displayed in the window.
2. Input Major and Minor Snow Parameters in Current Simulation Panel textboxes through one of the the following methods:
 - a. Manual Entry
 - b. Use ‘Transfer Params’ button in Optimization Panel to copy parameters found from an optimization to the Current Simulation Panel.
3. Input Site Location (Latitude and Height).
4. Press ‘Execute’ to run simulation and plot results. If snow depth measurement data is included in the data file, ‘Measured’ snow depth will be plotted with ‘Modeled’ results.
5. Use ‘Edit Figure’ button to launch figure in a separate window to edit/save plot to file.

1.2 Snow Parameter Optimization Instructions

In order to calculate least-squared optimized Snow Model parameters using Daily Precipitation [mm], Average Ambient Data [°C], SWE [mm] and Snow Depth [mm] measurements:

1. In the optimization panel, press ‘Data File...’ and select relevant ‘.csv’ Measurement file. The selected file name and directory will be displayed in the window.
2. Enter Latitude [°] and Height [m] for the Site Location.
3. If required, the optimization parameter bounds and initial guesses can be changed:
 - a. Press ‘Optimization Settings’ to change Upper and Lower Bounds of the parameters during run. Default values are valid for most site locations. To keep a certain parameter constant, set the upper and lower bounds to the same value.
 - b. The initial guesses for the Optimization can be altered by changing values in the Major and Minor Snow parameter textboxes in the Optimization panel. If not provided, the default initial guess is the mean of the upper and lower bounds.
4. Press ‘Optimize’ to run parameter optimization.

- a. Optimization progress window will be initiated plotting the current value of the optimization function. The optimization can be stopped or paused as required.
 - b. The optimization occurs to fit the modeled SWE onto the measured SWE data.
5. Optimized parameters will be displayed in the Major and Minor Snow Parameter textboxes in the Optimization panel. A plot of the measured snow depth and the modeled snow depth will be displayed in the window.
6. Use 'Edit Figure' button to launch figure in a separate window to edit/save plot to file.

2 Current Simulation Panel

The screenshot shows the SnowDepth - Model1 software interface. At the top, there are three buttons: 'New', 'Load', and 'Save'. To the right, there is a 'Help' button. Below these buttons is a large plot area showing 'Snow depth [mm]' on the y-axis (0 to 2500) and months on the x-axis (Oct to Aug). Two lines are plotted: a blue line for 'Measured' data and a red line for 'Modeled' data. To the right of the plot is a control panel with several sections: 'Major Snow Parameters' (with five input fields: 1.656, 1.293, 0.232, 1.350, 0.185), another 'Major Snow Parameters' section (with four input fields: 0.097, 0.215, 0.955, 0.050), 'Site Location' (with two input fields: 45.270, 2706.200), a 'Data File...' field containing 'C:\SnowDepthWorkingFolders\LM1314.csv', and an 'Execute' button. There are also 'Edit Figure' and 'Data File...' buttons.

Callout boxes provide the following explanations:

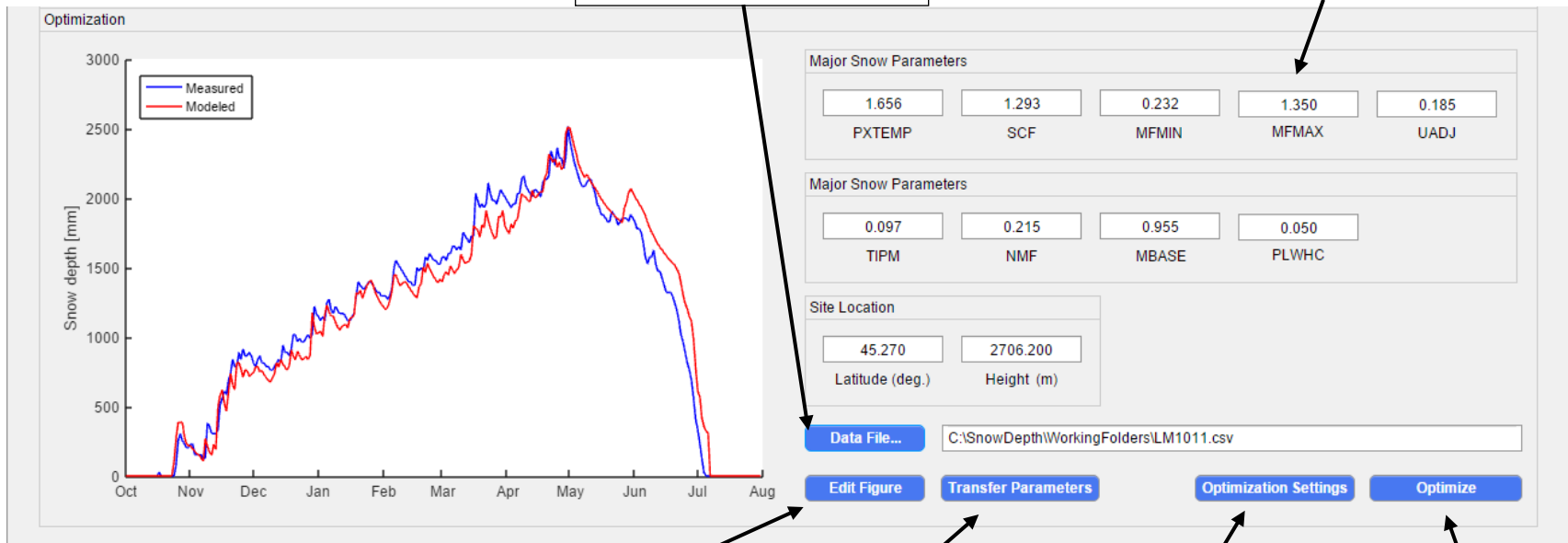
- New:** Reset all values in window
- Load:** Load “.mat” file containing a previously stored session.
- Save:** Save current session to a “.mat” file for future use.
- Help:** Allows user to launch this User Guide or the SnowDepth Theory Documentation.
- Plot:** Displays Results of Simulation. If Measured Snow Depth is included in Measurement File, both ‘modeled’ and ‘measured’ data is plotted as shown.
- Edit Figure:** Launches figure in a different window so that it can be edited and saved to file.
- Data File...:** Load “.csv” file with Daily Precipitation and Temperature Measurement Data.
- Execute:** Calculates the Snow Depth predictions for Measurements File displayed, “LM1314.csv” in this case, for the input Parameters.

3 Parameter Optimization Panel

Please Note: Site Location information is required for optimization.

Load “.csv” file with Daily Precipitation, Temperature, SWE and Snow Depth Measurement Data

Contains optimization results. These parameters are also used as the initial guesses for the optimization. If not provided, the initial guesses are the mean of the upper and lower



Displays Results of Optimized Parameters for Measurement File “LM1001.csv”.

Launches figure in a different window so that it can be edited and saved to file.

Copy parameters in Optimization Panel for Current Simulation

Opens Optimization Settings window where the Upper and Lower bounds of the Snow Model parameters during optimization can be set.

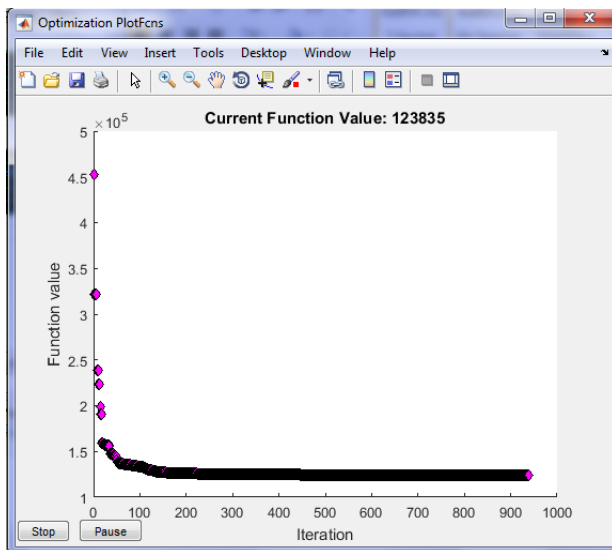
Opens optimization progress window shown below. Calculates the least-square optimization of the snow model parameters to fit measured and modeled SWE. Results are filled into the Optimization Panel

4 Optimization Progress Window

The current value of the function is displayed while optimization is in progress. The run will finish for the following tolerance conditions:

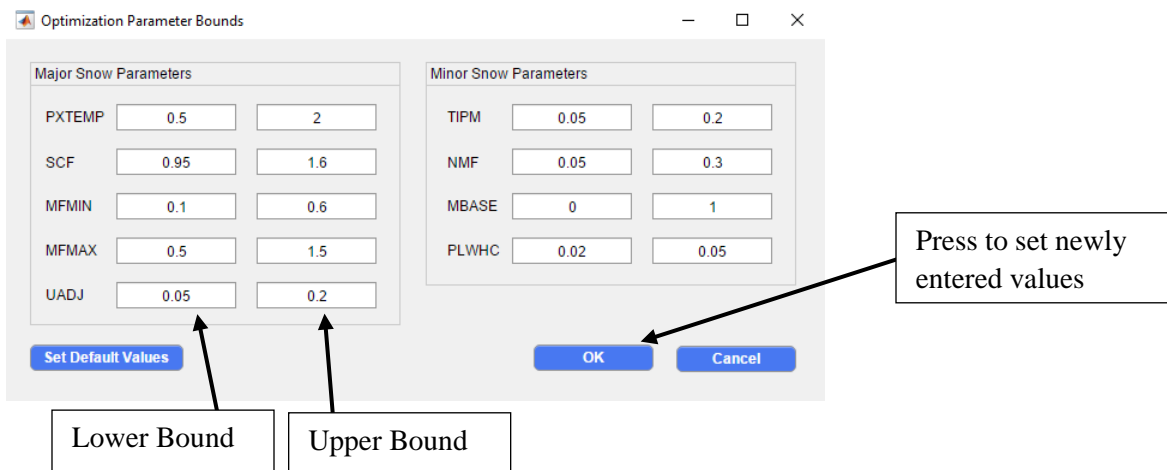
1. The solver attempts a step change in parameter value of $TolX = 1e-4$
2. The function value changes by $TolFun = 1e-2$
3. Maximum number of $1e4$ iterations is reached

Use stop button close the optimization and output the parameters on the current iteration. The simulation can also be paused using the 'Pause' button.



5 Optimization Settings Window

This window allows the upper and lower bounds for optimization of the Snow Parameters to be set. Default values are provided which are valid for most locations; see SnowDepth Documentation for more details. In order to set a parameter to a constant during optimization, set both upper and lower bounds to the same value.



6 Data Input Details

The data files are required in ‘.csv’ format with following format and units.

Date	Daily Precipitation	Average Daily Temperature	Snow Depth	Snow Water Equivalent (SWE)
yyyy-mm-dd	mm	°C	mm	mm

The column order should be as provided above. The first line of the data file will not be read; column titles may be placed here. Please ensure the Dates are provided in the same format as shown.

The Snow Depth and SWE measurements are not required for the ‘Current Simulation Panel’. Measured snow depth data may be provided in the fourth column if the user wants to plot the data alongside simulated results; SWE measurements may be provided or left empty. An example file is shown below opened in Excel and Notepad:

	A	B	C	D	E	F
1	Date	Daily Precip (mm)	Temp (deg. C)	Snow Depth (mm)	SWE (mm)	
2	2013-10-01	5.08	2.22222222	0	0	
3	2013-10-02	0	0.55555556	0	0	
4	2013-10-03	12.7	-2.77777778	0	0	
5	2013-10-04	2.54	-3.33333333	177.8	15.24	
6	2013-10-05	5.08	0.55555556	127	17.78	
7	2013-10-06	0	5.55555556	76.2	22.86	
8	2013-10-07	0	7.22222222	50.8	22.86	
9	2013-10-08	0	1.66666667	25.4	22.86	
10	2013-10-09	0	1.66666667	25.4	20.32	
11	2013-10-10	0	2.77777778	25.4	20.32	
12	2013-10-11	0	-1.11111111	25.4	20.32	
13	2013-10-12	0	-1.11111111	25.4	20.32	
14	2013-10-13	10.16	-0.55555556	25.4	20.32	
15	2013-10-14	0	-2.22222222	127	33.02	
16	2013-10-15	0	-2.22222222	127	33.02	
17	2013-10-16	5.08	-0.55555556	101.6	30.48	
18	2013-10-17	5.08	-2.77777778	101.6	35.56	
19	2013-10-18	5.08	-0.55555556	177.8	40.64	
20	2013-10-19	0	3.88888889	152.4	43.18	
21	2013-10-20	0	1.11111111	127	43.18	
22	2013-10-21	0	3.33333333	127	43.18	
23	2013-10-22	0	6.11111111	101.6	43.18	
24	2013-10-23	0	5.55555556	101.6	43.18	
25	2013-10-24	0	6.66666667	101.6	43.18	

```

LM1314 - Notepad
File Edit Format View Help
/Date,Daily Precip (mm),Temp (deg. C),Snow Depth (mm),SWE (mm)
2013-10-01,5.08,2.22222222,0,0
2013-10-02,0,0.55555556,0,0
2013-10-03,12.7,-2.77777778,0,0
2013-10-04,2.54,-3.33333333,177.8,15.24
2013-10-05,5.08,0.55555556,127,17.78
2013-10-06,0,5.55555556,76.2,22.86
2013-10-07,0,7.22222222,50.8,22.86
2013-10-08,0,1.66666667,25.4,22.86
2013-10-09,0,1.66666667,25.4,20.32
2013-10-10,0,2.77777778,25.4,20.32
2013-10-11,0,-1.11111111,25.4,20.32
2013-10-12,0,-1.11111111,25.4,20.32
2013-10-13,10.16,-0.55555556,25.4,20.32
2013-10-14,0,-2.22222222,127,33.02
2013-10-15,0,-2.22222222,127,33.02
2013-10-16,5.08,-0.55555556,101.6,30.48
2013-10-17,5.08,-2.77777778,101.6,35.56
2013-10-18,5.08,-0.55555556,177.8,40.64
2013-10-19,0,3.88888889,152.4,43.18
2013-10-20,0,1.11111111,127,43.18
2013-10-21,0,3.33333333,127,43.18
2013-10-22,0,6.11111111,101.6,43.18
2013-10-23,0,5.55555556,101.6,43.18
2013-10-24,0,6.66666667,101.6,43.18
2013-10-25,0,6.11111111,101.6,43.18
2013-10-26,0,6.11111111,101.6,43.18
2013-10-27,0,3.88888889,101.6,43.18
2013-10-28,2.54,-5.76,2.43,18
2013-10-29,0,-2.22222222,101.6,45.72
2013-10-30,0,-1.66666667,101.6,45.72
2013-10-31,10.16,-1.66666667,101.6,45.72
2013-11-01,0,-1.11111111,203.2,60.96
2013-11-02,5.08,0.55555556,203.2,63.5
  
```