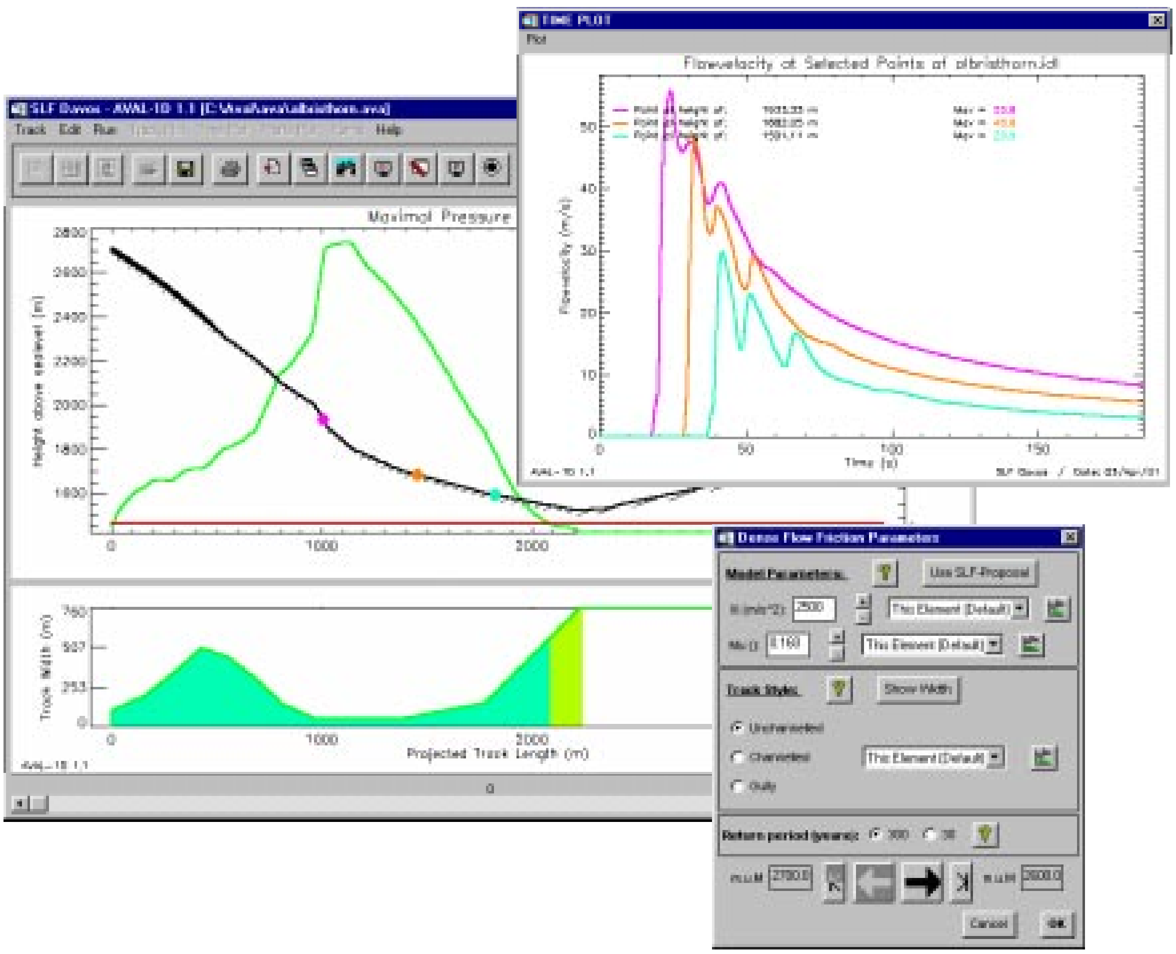
AVAL-1D

Numerical calculation of dense flow and powder snow avalanches

Marc Christen, Perry Bartelt and Urs Gruber



Swiss Federal Institute for Snow and Avalanche Research, Davos, Switzerland

Contents

1 Introduction

AVAL-1D is the new numerical avalanche dynamics program developed by the Swiss Federal Institute for Snow and Avalanche Research (SLF) in Davos.The program calculates run-out distances, velocities and pressures exerted by dense flow and powder snow avalanches.

AVAL-1D results from many years of research. In 1995 the SLF started to use one-dimensional, numerical models to determine the run-out distances and dynamic pressures of dense flow avalanches. The numerical dense flow avalanche model was developed until 1997 and a graphic user interface was added to allow visualisation of the results. The first version of AVAL-1D was tested on the basis of numerous historical avalanches and with examples from *B. Salm, A. Burkard und H.U. Gubler, Berechnung von Fliesslawinen, Eine Anleitung fuer Praktiker mit Beispielen*.The program was also used at the SLF to establish expertises on avalanche damages. Until 1998 - before the extreme avalanche winter of 1998/99 - over 100 problems relating to avalanche dynamics were investigated and the program was then ready to be used for practical applications.

The development of physically based powder snow avalanche models was effected in collaboration with the *Versuchsanstalt fuer Wasserbau* at the ETH Zuerich between 1982 and 1995 and then by the SLF alone. As there was a general lack of measurements on real powder snow avalanches, investigations on model avalanches were effected in a water tank. As from 1992 there were enough efficient fluid-dynamics programs available to allow the development of a 3-dimensional calculation model. This model, called SL-3D has been used since then for expert reports and allows detailed modelling of the spatial distribution of the powder constituents. Calculations and visualisation of the results are relatively complicated and time-consuming and advanced knowledge of fluid dynamics and numerical methods are required.

In comparison with SL-3D, the description of snow entrainment was significantly improved in SL-1D, whereas the lateral extension and modifications of vertical profiles were neglected. AVAL-1D integrates the dense flow and the powder snow avalanche models in one single user interface. This allows calculations to be effected and analysed rapidly and easily on normal PCs. It should be mentionned that the quality of available data has not improved significantly since the eighties and that SL-1D could therefore not be tested as thoroughly as FL-1D. It is therefore necessary to have a certain amount of knowledge in the field of avalanches in order to use AVAL-1D successfully.

AVAL-1D 1.0 was presented to practitioners in the context of a course entitled *„Neue Berechnungsmethoden in der Lawinengefahrenkartierung“*, in Davos, Switzerland in November 1999. The first update 1.1 with an improved graphical user interface was introduced in February 2001. In october 2001, a first user workshop was held in Davos. New ideas were taken from the workshop and implemented in the update 1.2, which is available since april 2002.

The user interface (see Figure 1) was programmed using IDL (Interactive Data Language, a portable software for data analysis and visualization),to make the transfer of the program to other computer systems easier. AVAL-1D consists of three modules:

- **INPUT:** The topography of the avalanche, its release conditions and the model parameters (coefficients of friction) can be entered using dialogue windows, text files or even topographic maps. The avalanche track can be modified very easily and the model parameters can be adapted. This allows the user to investigate the influences of

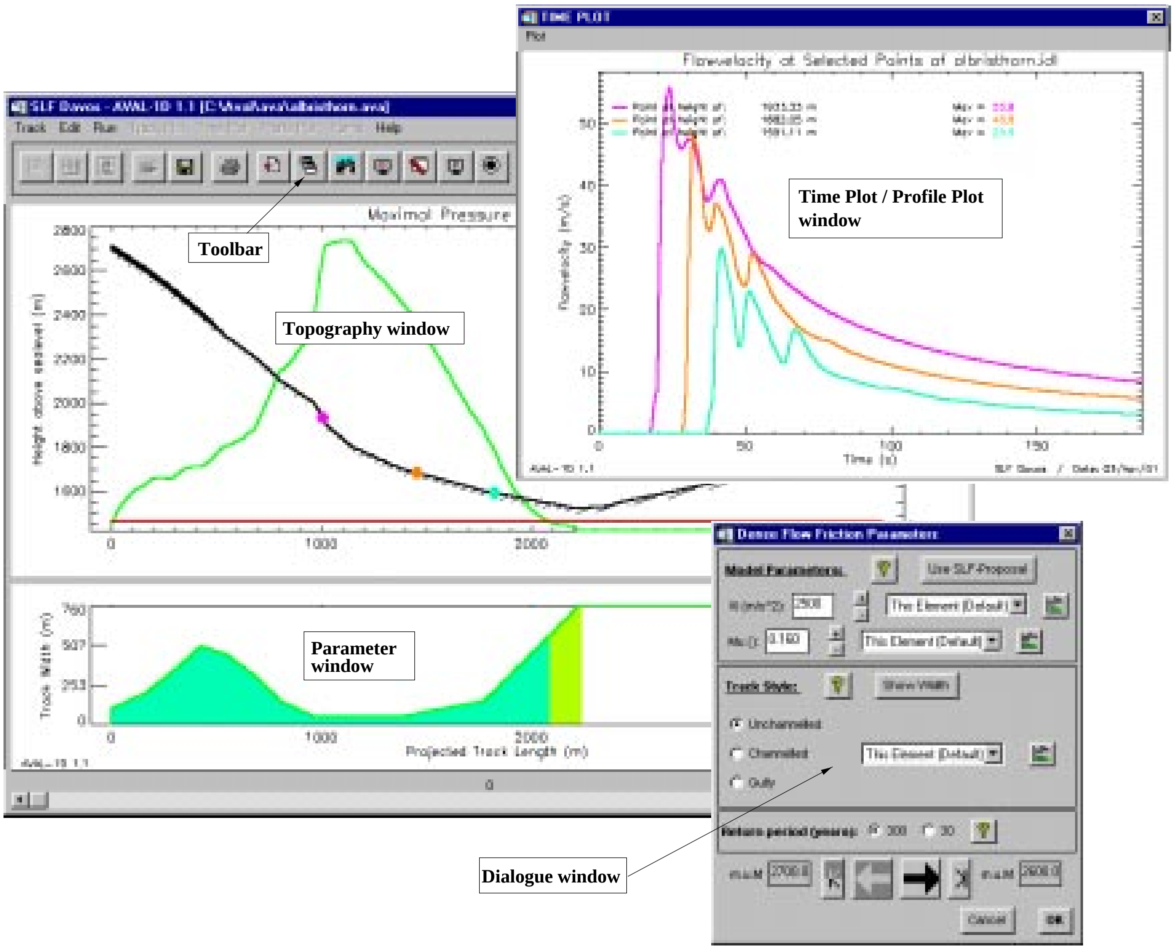


Figure 1: `AVAL-1D` user interface.

topography and parameter variations on simulation results very efficiently.

- **CALCULATION:** `AVAL-1D` contains two independent calculation modules, `FL-1D` for dense flow avalanches and `SL-1D` for powder snow avalanches, which have both been programmed in C. Both `FL-1D` and `SL-1D` solve differential equations, which describe conservation of mass, energy and movement using the finite difference method.
- **OUTPUT:** The results of the numerical calculations are velocity and pressure (of the avalanche front), density, height and length of the avalanche. Runout distances and mass distribution are also very important. All these results can be visualised and printed.

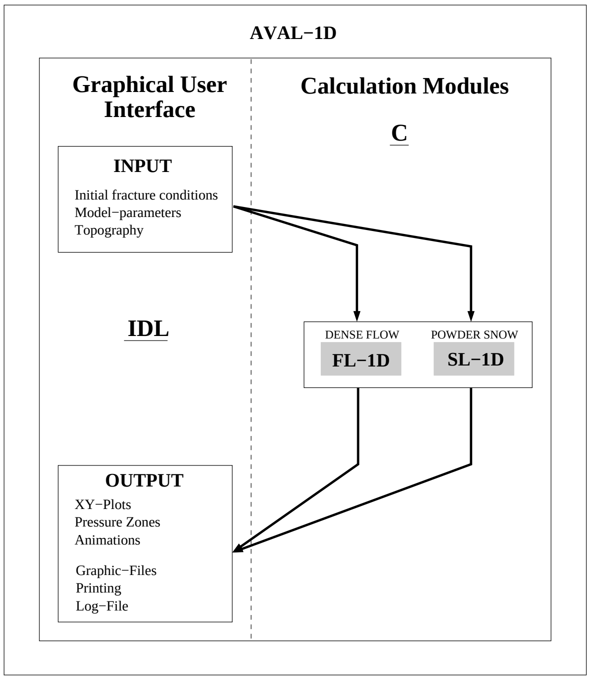


Figure 2: Schematic representation of AVAL-1D.

The AVAL-1D - handbook is divided into the following chapters:

1. **Introduction**

2. **AVAL-1D User interface**

   The user interface in AVAL-1D, the pulldown-menus, the dialogue windows, topography windows, time plots / profile plots and the toolbar are explained here. (see Figure 1).

3. **Input mode**

   Chapter 3 explains how a new topography can be entered, how an existing topography can be opened and model parameters entered and how the calculation can be started. Reference is constantly made to the calculation example (see appendix A).

4. **Choice of numerically relevant parameters**

   This important chapter explains which parameters are important for the numerical calculation and how they should be chosen to allow a stable calculation run.

5. **Results**

   The possibilities of representation of results of the dense flow part (DENSE FLOW-mode) and the powder snow part (POWDER SNOW-mode) are shown here.

6. **Miscellaneous**

   How can results be printed or saved in a graphic file? What is *parameter.dat*? What's in the log file and how do you calculate avalanche arms? These questions are discussed in chapter 6.

7. **Appendix A: Example**

   This chapter is very important as it contains an example in which every single step is described. It is important to use this example as an excercise before you start calculating your own examples.

For questions, suggestions and criticism please contact:
Tel.: +41 (0)81 417 02 66 or e-mail: aval1d@slf.ch

2 AVAL-1D User interface

2.1 General

AVAL-1D can be used in three different modes:

- INPUT - mode (input and parameter mode),
- DENSE FLOW - mode (visualisation of the dense flow avalanche results) and
- POWDER SNOW - mode (visualisation of the powder snow avalanche results).

Before a calculation can be started, a new topography must be entered in the INPUT-mode (see chapter 3.1, p. 35), or an existing topography must be opened. The different parameters for dense flow and powder snow avalanches are also specified here. When all parameters have been entered, the calculation can be started (either a dense flow or powder snow avalanche calculation). The program then automatically switches to the appropriate results mode (either DENSE FLOW or POWDER SNOW), in order to display the results (see Figure 2).

If calculations have already been effected, a result file (ending with '*.idl' for dense flow avalanches or '*.idp' for powder snow avalanches) can be opened directly and the INPUT-mode can thus be avoided. (see chapter 5).

AVAL-1D has pulldown-menus, which can be activated with the mouse. Functions which are not available in the current context automatically become insensitive and can not be used. Windows in which input can or must be entered are referred to as 'dialogue windows'. Special functions such as zooming or selecting points are always commented on step by step in an info-window.

Since AVAL-1D 1.1 a toolbar and the right mouse button are available. The most important functions are accessible via these two helps (you don't have to use the menu all the time). Please refer to chapter 2.9 und 2.10 for help about the toolbar or right mouse button.

All main menus and sub-menus are presented and explained below. The symbol **'>'** indicates that further sub-menus exist. An indication such as **Track** → **New...** indicates that the sub-menu **New...** should be chosen in the main menu **Track**. In case a function is also accessible over the toolbar or the right mouse button, a little image is shown on the right side of the page (toolbar) or it is marked in the text (right mouse button). Figure 3 shows the AVAL-1D user interface with the pulldown menus.

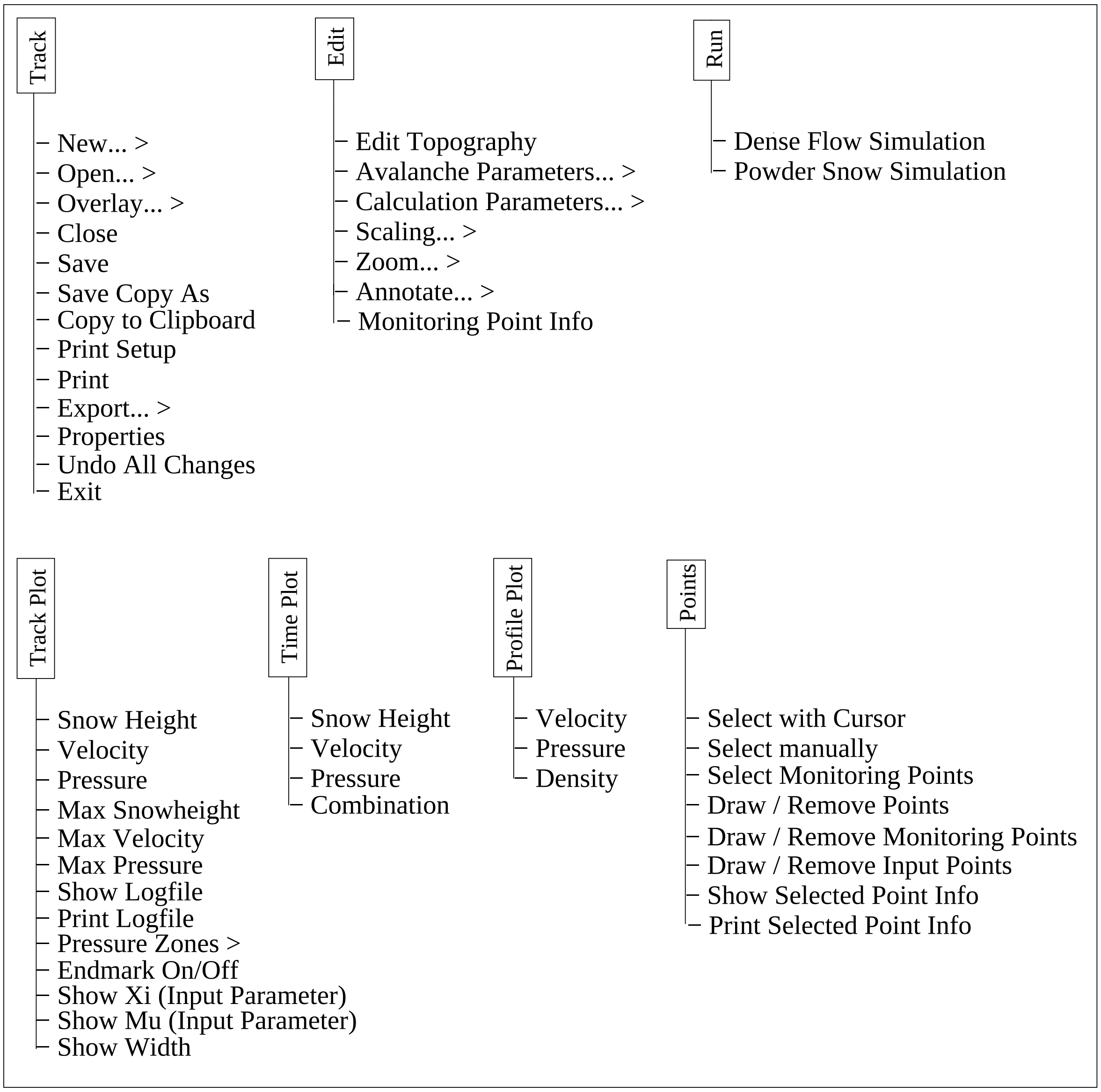


Figure 3: Pulldown menus in AVAL-1D.

2.2 Track - Menu

2.2.1 Track

Track
- New... >
- Open... >
- Overlay... >
- Close
- Save
- Save Copy As
- Copy to Clipboard
- Print Setup
- Print
- Export... >
- Properties
- Undo All Changes
- Exit

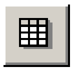
The pulldown menu **Track** is the core of the user interface in `AVAL-1D`. This is where different topographies can be entered, saved, stored, printed, closed and where `AVAL-1D` can also be quit. When `AVAL-1D` is launched, only **Track** → **New...** and **Track** → **Open...** are activated.

2.2.2 Track → New...

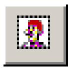
New...
- Create Points
- Read from Table
- Read from Image

A new topography can be created in three different manners:

Track → **New...** → **Create Points**: The topography is specified point by point via a dialogue window (see chapter 3.1.1, p. 35).



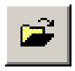
Track → **New...** → **Read from Table**: The topography is read from a table (see chapter 3.1.2, p. 38).



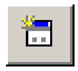
Track → **New...** → **Read from Image**: The topography is read directly from a digital map (see chapter 3.1.3, p. 39).

2.2.3 Track → Open...

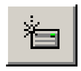
Open...
- Input File
- Dense Flow Simulation
- Powder Snow Simulation



With **Track** → **Open...** → **Input File** an existing topography is opened, see chapter 3.2, p. 43.



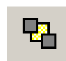
Track → **Open...** → **Dense Flow Simulation** opens an already existing dense flow avalanche calculation (with the ending `'*.idl'`, see chapter 5.1, p. 61).



Track → **Open...** → **Powder Snow Simulation** loads a powder snow avalanche calculation (with the ending `'*.idp'`, see chapter 5.2, p. 65).

2.2.4 Track → Overlay...

Overlay...
- Add New File
- Remove Last File



Track → **Overlay...** → **Add New File** allows to overlay several simlations.

Track → **Overlay...** → **Remove Last File** allows to remove the simulation run added last.

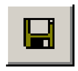
> **!!! BEWARE !!!**
> The files which are to be overlayed must contain *exactly the same topography and the same number of calculation steps*. Otherwise an error signal occurs and overlaying is not possible (see parts 5.1.3, p. 63 and 5.2.4, p. 70 for more detailed information)! **Track** → **Overlay...** → **Remove Last File** allows removal of the last added file.

2.2.5 Track → Close

The current file is closed but AVAL-1D is still open. A new file can be opened.

2.2.6 Track → Save

The **Track → Save** function is only active in the `INPUT` mode, the file is saved under its current name.



2.2.7 Track → Save Copy as

With **Track → Save Copy as** you can save your actual file, by choosing a new name, but stay with your current file within `AVAL-1D`. (Example: you are working with a file called *example.ava*. After 30 minutes, you want to save the actual state. Choose **Track → Save Copy as**, save your file as *test.ava* and continue to work with *example.ava*).

2.2.8 Track → Copy to Clipboard

Track → Copy to Clipboard copies the content of the upper window into the clipboard and can then be pasted into Word or a graphics program. Looking at results, also time-plot and profile-plot windows can be copied into the clipboard.

2.2.9 Track → Print Setup

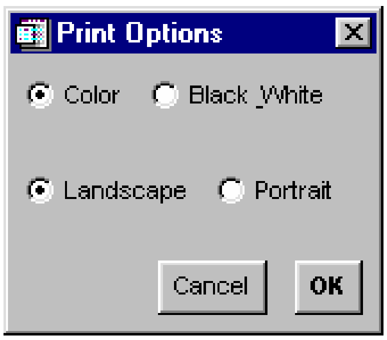


Figure 4: **Track → Print Setup** dialogue window.

In general, plots are printed or exported in colour. If you want to print on a black-and-white printer, choose **Black-White** in **Track → Print Setup**.After that, the plots will not be in colour any more, but dotted and dashed. It's also possible to export black-and-white EPS-files.

!!! Attention !!!
GIF-, TIFF- and BMP-files are not exportable in black-and-white.

Topography-plots are printed and exported in landscape-mode (cross-format). You can change that by clicking the second position on **Portrait**.

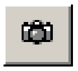
> **!!! Attention !!!**
> Timeplots and Profileplots are always printed in portrait-mode.

2.2.10 Track → Print

Choosing this function, the Windows print dialogue appears (see Figure 57, p. 71). Choose a printer and send the print job. The whole user interface will be printed.

2.2.11 Track → Export...

Export...
- Display
- Data
- Simulation

With **Track** → **Export...** → **Display** the dialogue window in Figure 5 appears. 

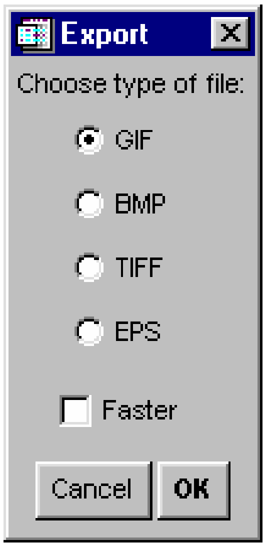
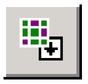


Figure 5: **Track** → **Export...** → **Display** dialogue window.

At present four different graphic formats can be chosen: `GIF, BMP, TIFF and EPS`. These graphic files can then be inserted in Word e.g..

The most important results can also be exported as `ASCII`-files (**Track** → **Export...** → **Data**). A name is suggested in the dialogue window (e.g. `Example.txt`), which is however not obligatory and can be modified. This `ASCII`-file can then for example be read and worked on in Excel (see chapter 6.1, p. 72).

Track → **Export...** → **Simulation** is only available in dense flow mode (when a dense flow simulation is open). With this function it is possible to increase or decrease the snow mass along the avalanche path (e.g. to calculate avalanche arms, see chapter 6.4, S. 87.



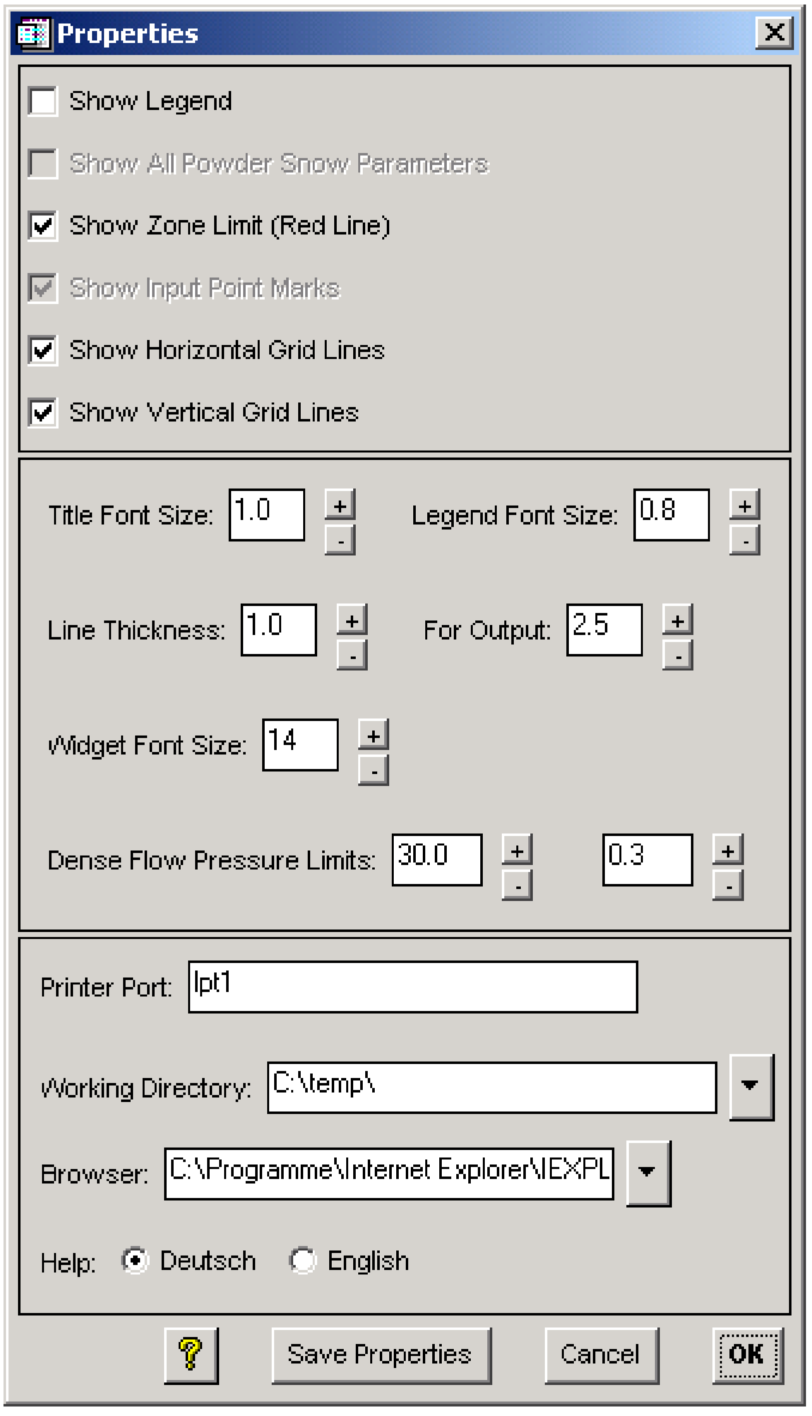


Figure 6: **Properties** dialogue window.

2.2.12 Track → Properties

General settings (like line thickness, title and legend font size, printer port, working directory etc.) can be changed and saved here (see Figure 6). This function is also available by right mouse button. All properties are saved in the file *properties.dat*, located in the ∼ *Rsi**Idl52**lib**hook* directory. When you start AVAL-1D this file is read and your personal settings are used.

- **Show Legend:**

  The snowheight legend can be switched on and off.

- **Show All Powder Snow Parameters:**

  The powder snow parameter dialogue window is reduced and the suspension layer parameters have been removed. If you nevertheless want all parameters, activate this button.

- **Show Zone Limit (Red Line):**

  This function was introduced especially for countries, which don't have pressure zone limits (red-blue at 30 KPa in Switzerland). Deactivating this button causes the red line to vanish.

- **Show Input Point Marks:**

  The input points can be marked with red points by enabling or disabling the appropriate checkbox.

- **Show Horizontal Grid Lines:**

  By enabling or disabling the appropriate checkbox horizontal gridlines can be activated or not.

- **Show Vertical Grid Lines:**

  By enabling or disabling the appropriate checkbox vertical gridlines can be activated or not.

- **Title Font Size:**

  This value influences all plot title font sizes within AVAL-1D (plot-title, x-axes-title, y-axes-title......).

- **Legend Font Size:**

  This value influences all other text font sizes (legends, annotations, etc.).

- **Line Thickness:**

  This value changes all line thicknesses (on the screen!).

- **For Output:**

  Changing the line thickness during printing, 2.5 seems to be not bad, try out!

- **Widget Font Size:**

  This value changes the font size within the dialogue windows in AVAL-1D.

- **Dense Flow Pressure Limits:**

  Definition of red-blue and blue-white pressure limits. With **Save Properties** the pressure limits are saved in the properties-file. These values are also saved in the input file.

- **Printer Port:**

  This field is used to choose your printer port. See chapter 6.2, S. 75 for details.

- **Working Directory:**

  Choose your personnel working directory here. Press **Browse** to choose a new directory. Each time you start `AVAL-1D`, the default directory will be always your working directory.

- **Internet-Browser - exe-file**

  Choose your internet browser's exe-file. Press **Browse** to choose a new file, e.g. *C:* \ *Programme* \ *Internet Explorer* \ *iexplore.exe*. You need the internet browser to visualize the help menu.

- **Help**

  The help-menu is available in German and English!

By pressing **Save Properties** all your settings are saved!!

2.2.13 Track → Undo All Changes

Undo All Changes resets your file to the original condition, in case you find out that all the changes you have made since opening the file are useless.

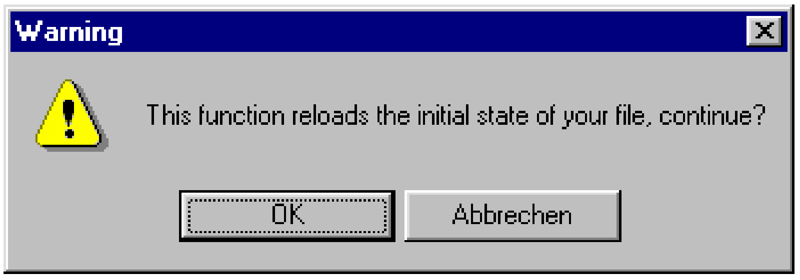


Figure 7: After pressing **Track→Undo All Changes** this warning box pops up.

2.2.14 Track → Exit

Quit `AVAL-1D`.

2.3 Edit - Menu

2.3.1 Edit

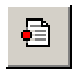
Edit

- Edit Topography
- Avalanche Parameters... >
- Calculation Parameters... >
- Scaling >
- Zoom >
- Annotate >
- Monitoring Point Info

The sub-menus **Edit Topography, Avalanche Parameters...** and **Calculation Parameters...** are only active in the INPUT-mode (in this version). Using the pulldown menu **Edit**, the window can be scaled(**Scaling...**), zoomed (**Zoom...**) and completed with text (**Annotate...**).

2.3.2 Edit → Topography

This function, which is only active in the INPUT-mode, allows acces to the dialogue window **Edit Topography** (see Figure 8). Using the arrows, one can jump from point to point and the X-, Y- and Z-coordinates as well as the avalanche width can be changed directly (press ENTER after every value!!). Various other functions are possible, such as removing or adding points, setting markers, defining monitoring points etc. See chapter 3.3, p. 43 or appendix A.2, p. 94.



Monitoring Points This function is only important for dense flow simulations. It's possible to mark points of special interest as *monitoring points*.

To specify a monitoring point, choose **Edit Topography**, jump to the topography-point you want to set a monitoring point (with the arrows) and press **YES** at **M. Point ?**. A dialogue window appears (Monitoring Point Info, see Figure 9, dialogue window on the right) where a name must be specified. Observed flowheights and flowvelocities can be specified as well, but not necessarily.

The results of these points (flowheight and flowvelocity) will be written in a log file (together with general information such as chosen parameters, runout distances, etc.) and compared to the observed values (if specified). The log file can then be opened or printed out directly from within AVAL-1D (**Track Plot** → **Show Logfile** bzw. **Track Plot** → **Print Logfile**).

The **Monitoring Points** are saved in the INPUT-file, i.e. when the same INPUT-file is opened again later in order to calculate a similar simulation, the same **Monitoring Points** are available.

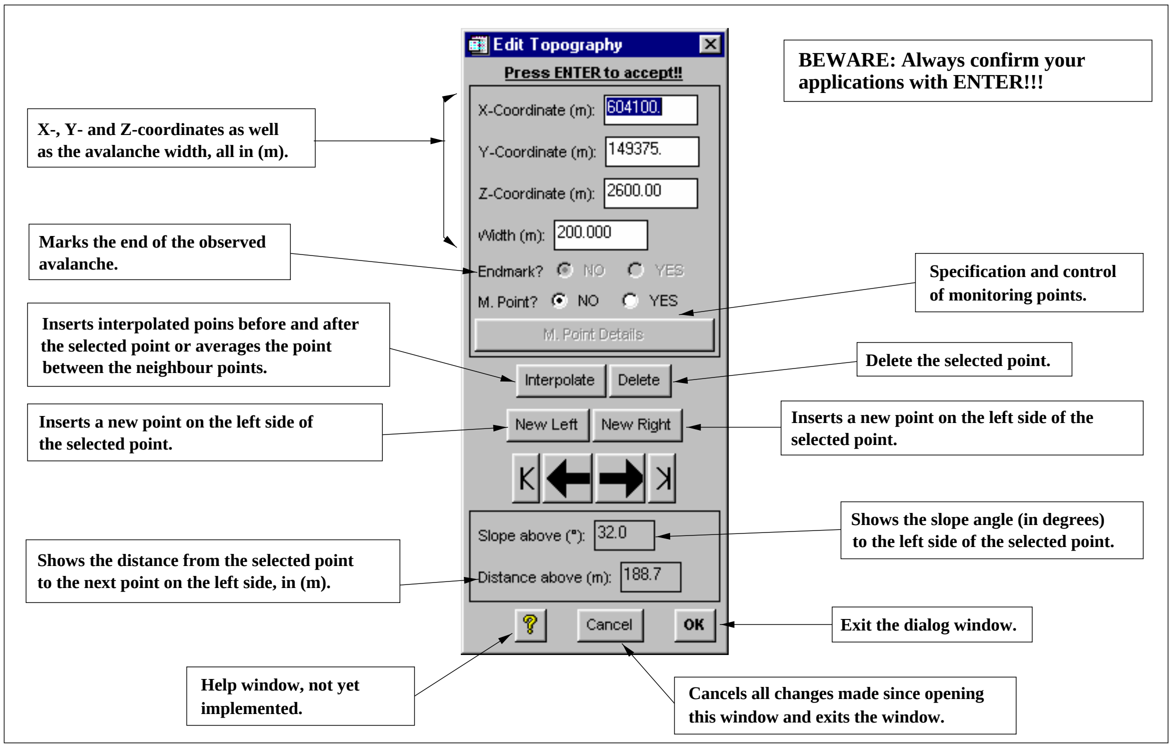


Figure 8: **Edit** → **Topography** dialogue window.

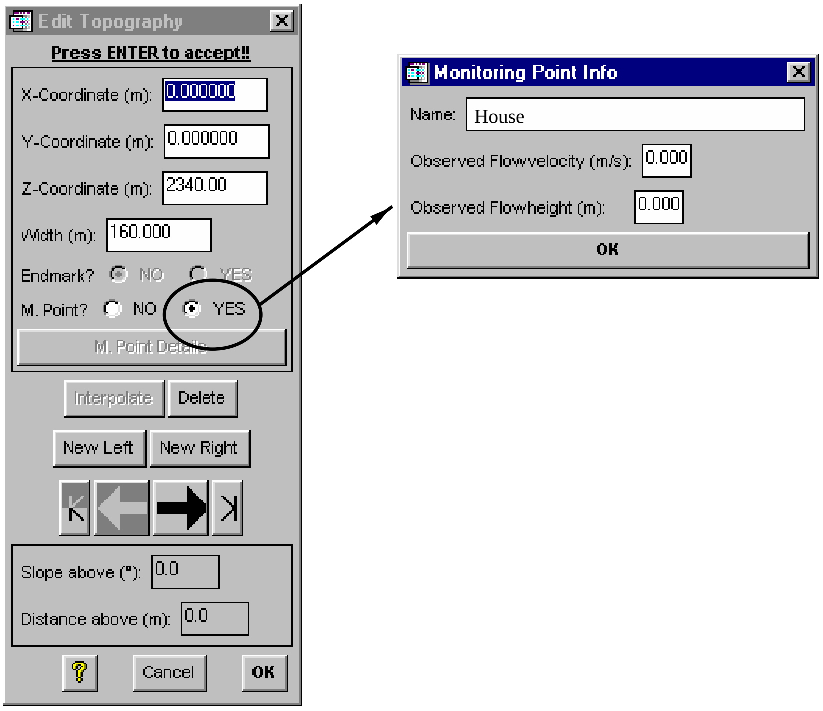
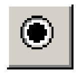


Figure 9: Enter monitoring points.

You can get information about the monitoring points by choosing **Edit** → **Monitoring Point Info** or clicking the **Monitoring Point** Info-Button.

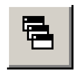


2.3.3 Edit → Avalanche Parameters...

Avalanche Parameters...
- Dense Flow - Release Zone
- Dense Flow - Xi/Mu
- Powder Snow

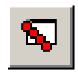
In the menu **Edit** → **Avalanche Parameters...** you can choose between

Dense Flow - Release Zone



Dense Flow - Xi/Mu

and **Powder Snow**.



The dialogue windows have different amounts and types of parameter which can be edited. More on this subject can be found in chapter 3.4, p. 46 or appendix A.3, p. 97. These functions are only active in the `INPUT`-mode.

2.3.4 Edit → Calculation Parameters...

Calculation Parameters...
- Dense Flow
- Powder Snow

Here you can choose between

Dense Flow

and **Powder Snow** calculation paremters.

Again the dialogue windows for these functions differ as the number and types of parameter which can be edited are different. Chapter 3.4, p. 46 and appendix A.4, p. 102 contain more details. This function is only acitve in the `INPUT`-mode.

2.3.5 Edit → Scaling...

Scaling...
- Change Scaling
- Avalanche Layers (Top Display)
- Scaled Layers (Bottom Display)

All results can be scaled. The shaded functions are only possible in the `POWDER SNOW`-mode (powder snow avalanches). These functions are also available with the right mouse button.

Figure 10 (a) shows the **Edit** → **Scaling...** → **Scaled Layers (Bottom Display)** dialogue window in `POWDER SNOW`-mode, Figure (b) the **Edit** → **Scaling...** → **Avalanche Layers (Top Display)** dialogue window in `POWDER SNOW`-mode and Figure (c) the **Edit** → **Scaling...** → **Change Scaling** dialogue window in `DENSE FLOW`-mode.

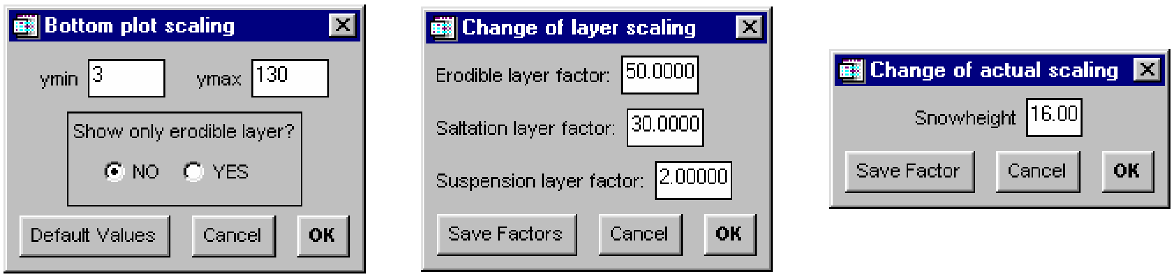


Figure 10: Different **Scaling**-dialogue windows in `POWDER SNOW`- and `DENSE FLOW`-mode.

2.3.6 Edit → Zoom...

Zoom...
- Box
- Box prop.
- Fullsize
- Fullsize prop.

Zooming can be effected in two different manners:

1. **Edit** → **Zoom...** → **Box**: the exact area which has been selected is zoomed (by selecting the top left corner and the bottom right corner of the zoom-box with the *left* mouse button).

2. **Edit** → **Zoom...** → **Box prop.**: the y-axis (z-coordinates) is scaled proportionally to the x-axis, i.e. the part of the y-axis does not exactly correspond to the part that has been selected.

The same applies to **Fullsize** and **Fullsize prop.**, which again show the whole topography. The functions **Edit** → **Zoom...** → **Box** and **Edit** → **Zoom...** → **Fullsize** are also available with the right mouse button.

!!! Attention !!!
The abbreviation **prop.** signifies **proportional**, i.e. a unit length on the x-axis corresponds exactly to a unit length on the y-axis.

2.3.7 Edit → Annotate...

Annotate...
- Top Display
- Bottom Display
- Delete All
- Delete Last Object
- Delete Last Text

Annotate means commenting, i.e. comments, arrows and lines can be inserted in the upper window (**Edit** → **Annotate...** → **Top Display**), or in the lower window (**Edit** → **Annotate...** → **Bottom Display**). The user has the possibility of commenting figures for reports or expertises. The dialogue window is shown in Figure 11.

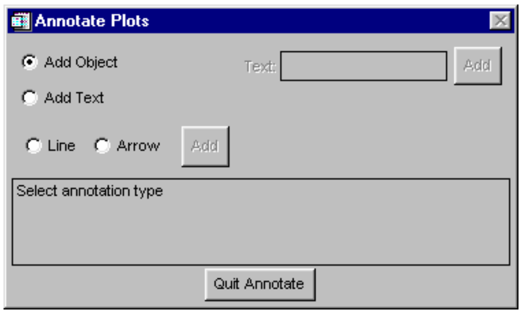
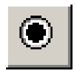


Figure 11: **Edit** → **Annotate...** dialogue window.

2.3.8 Edit → Monitoring Point Info



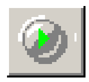
You can get information about the monitoring points by choosing this function. Check how many points you specified and where you specified them.

Figure 12: **Edit → Monitoring Point Info** Informations-Box.

2.4 Run - Menu

Run Calculation

- Dense Flow Simulation
- Powder Snow Simulation



Either a **Dense Flow Simulation** (Figure 13, left) or a **Powder Snow Simulation** (Figure 13, right) can be started from here (see also chapter 3.5, p. 54 or appendix A.6, p. 104).

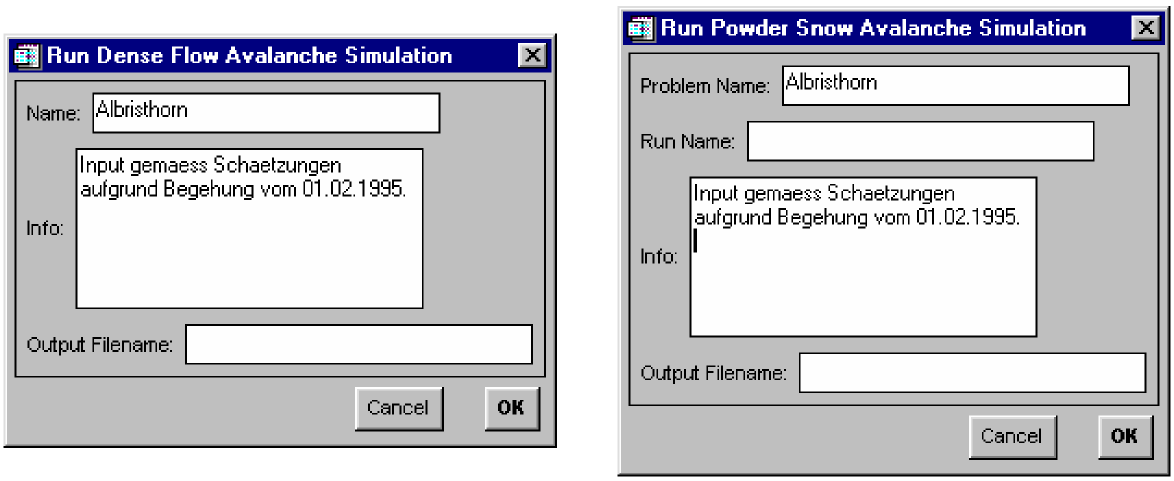


Figure 13: **Run Dense Flow** and **Run Powder Snow** dialogue window

2.5 Track Plot - Menu

Dense Flow

Track Plot
- Snow Height
- Velocity
- Pressure
- Max Snowheight
- Max Velocity
- Max Pressure
- Show Logfile
- Print Logfile
- Pressure Zones >
- Endmark On/Off
- Show Xi (Input Parameter)
- Show Mu (Input Parameter)
- Show Width

Powder Snow

Track Plot
- Snow Height
- Velocity
- Pressure
- Density
- Track Width − Bottom
- Track Width − On/Off
- Topography On/Off
- Print Logfile
- Max Values / Time Step Values

The pulldown menu **Track Plot** only becomes active after a successful simulation, or when a dense flow or powder snow calculation is opened directly.

2.5.1 Track Plot → Snow Height/Velocity/Pressure

`DENSE FLOW`-mode: Snowheight, velocity and pressure can be visualized in the upper window. The parameters are plotted over the topography and it's possible to animate them.

`POWDER SNOW`-mode: Additionally, also the density can be visulatized in the lower window. The three different powder snowheights (erodible, saltation and suspension layer) are always displayed in the upper window. As the results of a powder snow avalanche calculation are not constant over the avalanche height, the vertical heights of interest (in relation to the ground surface) have to be entered (see Figure 14). Also these results can be animated.

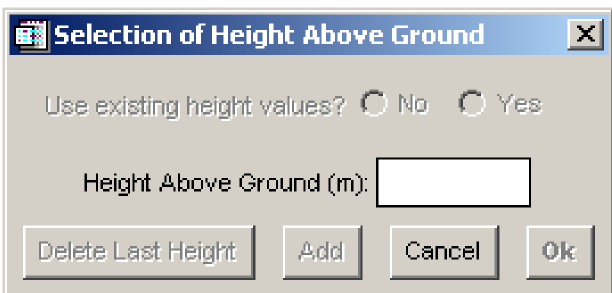


Figure 14: Dialogue window to select heights above ground.

2.5.2 Track Plot → Max Snowheight/Max Velocity/Max Pressure

These functions are only valid for `DENSE FLOW`-simulations. The maximum values of snowheight, velocity or pressure are plotted against the topography.

2.5.3 Track Plot → Show Logfile

The most important results as well as information about the reason for the end of the simulation, the input-file e.g. are written in a log file. This log file can be visualized directly from within `AVAL-1D`.

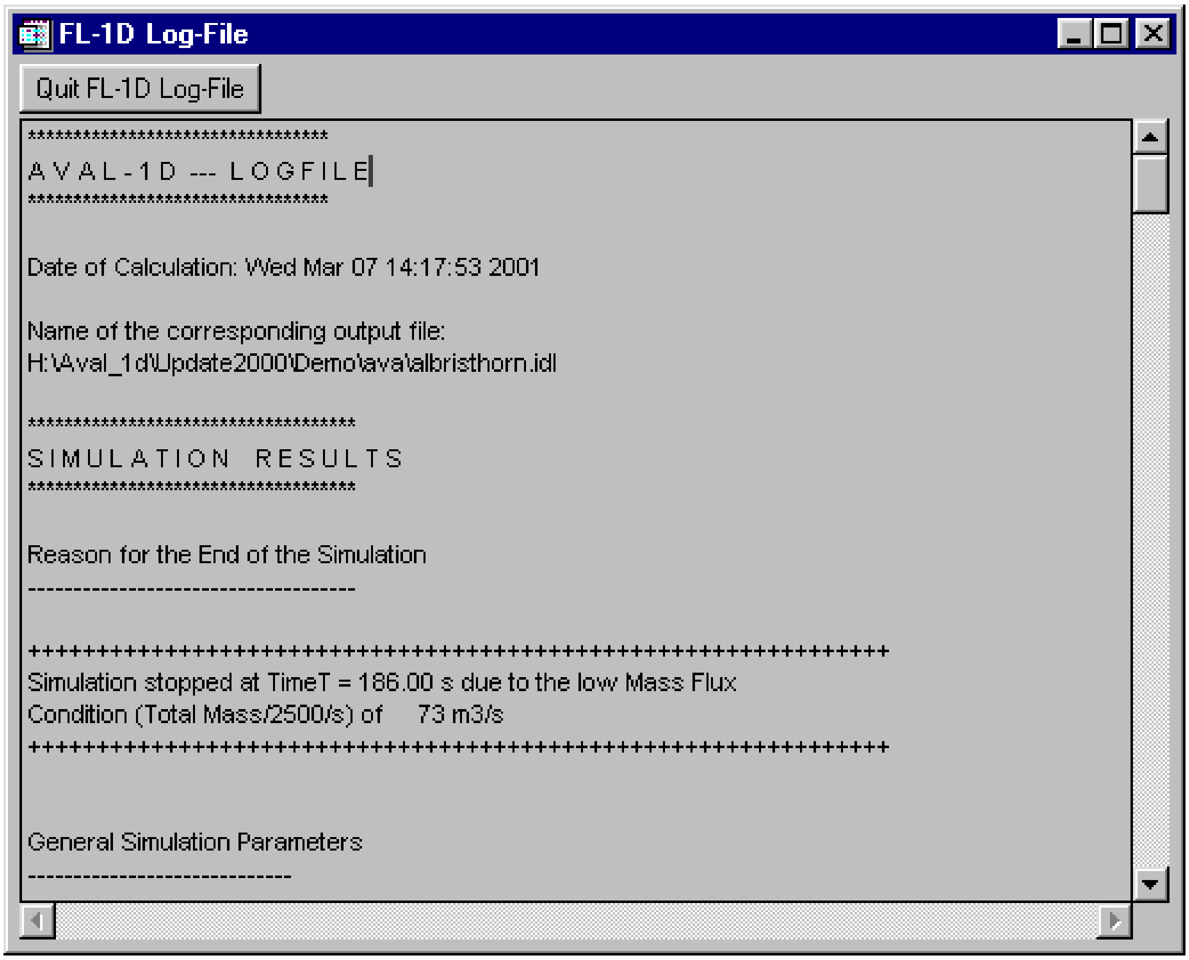


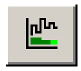
Figure 15: The dense flow log file informs about the most important results.

2.5.4 Track Plot → Print Logfile

Another possibility is to print the log file from within AVAL-1D. In case this is not working, please change your printer port in **Track** → **Properties** (see chapter 6.2, p. 75).

2.5.5 Track Plot → Pressure Zones...

Pressure Zones >
- On/Off
- Edit Value



In the DENSE FLOW-mode it is possible to display danger zones (in colour) in the lower window. The 30 kN / m^2-pressure value is used as a colour limit in Switzerland for the red / blue limit, 3 kN / m^2 for the blue / white limit. With **Track Plot** → **Pressure Zones...** → **On/Off** these colour limits can be switched on and off. This value can be modified interactively using **Track Plot** → **Pressure Zones...** → **Edit Value** or in the properties (**Track** → **Properties**, see Figure 6, S. 11).

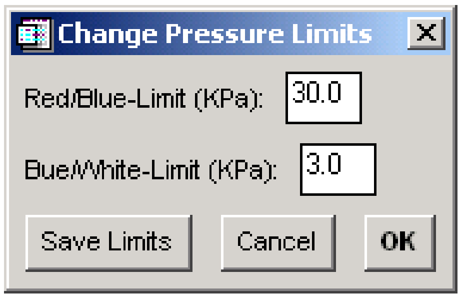
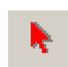


Figure 16: **Edit Value** dialogue window. Pressing **Save Limits** will save the pressure limits in *properties.dat*.

2.5.6 Track Plot → Endmark On/Off



Endmark On/Off allows to mark the end of the observed avalanche in order to be able to compare it with the calculated run-out area (see appendix A.2, p. 94). This function is only available in the DENSE FLOW-mode.

2.5.7 Track Plot → Show Xi (Input Parameter)

This function shows the input friction parameter Xi in the lower window.

2.5.8 Track Plot → Show Mu (Input Parameter)

This function shows the input friction parameter Mu in the lower window.

2.5.9 Track Plot → Show Width

This function shows the avalanche width in the lower window.

2.6 Time Plot - Menu

Dense Flow	Powder Snow
Time Plot	**Time Plot**
- Snow Height	- Snow Height
- Velocity	- Velocity
- Pressure	- Pressure
- Combination	- Density

Time Plot displays the temporal evolution of a result - e.g. (**Velocity**), in a separate window (see Figures 17 and 18), provided that one or more points along the topography were selected (see chapter 2.8, p. 27). For results in the `POWDER SNOW`-mode, the heights of interest must be entered again - see Figure 14, p. 20. The menu **Plot** within the **Time Plot** window is used to scale, annotate, print and export the graph. Exit the **Time Plot** window with **Plot** → **Quit** or by using the little cross in the upper right corner.

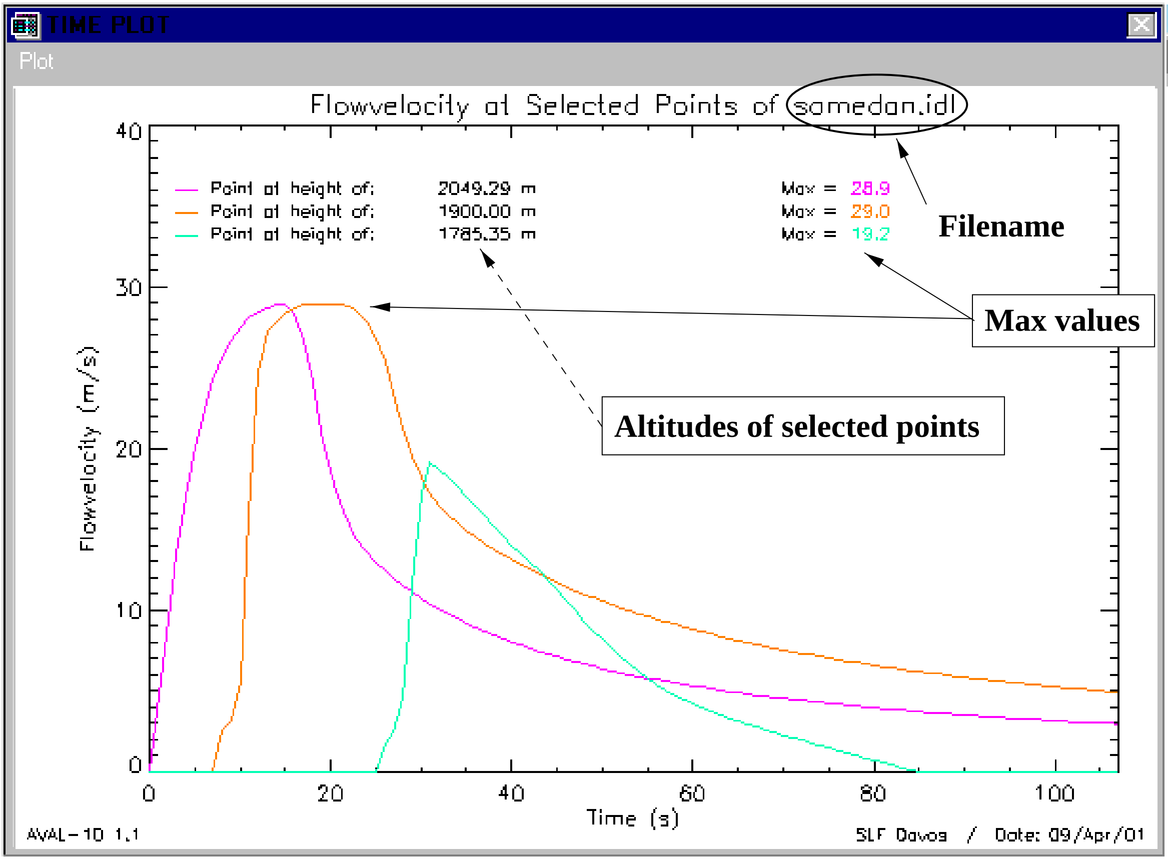


Figure 17: **Time Plot** window in the `DENSE FLOW`-mode. The development of velocity at three points is shown. The **Plot** menu is situated in the upper left corner.

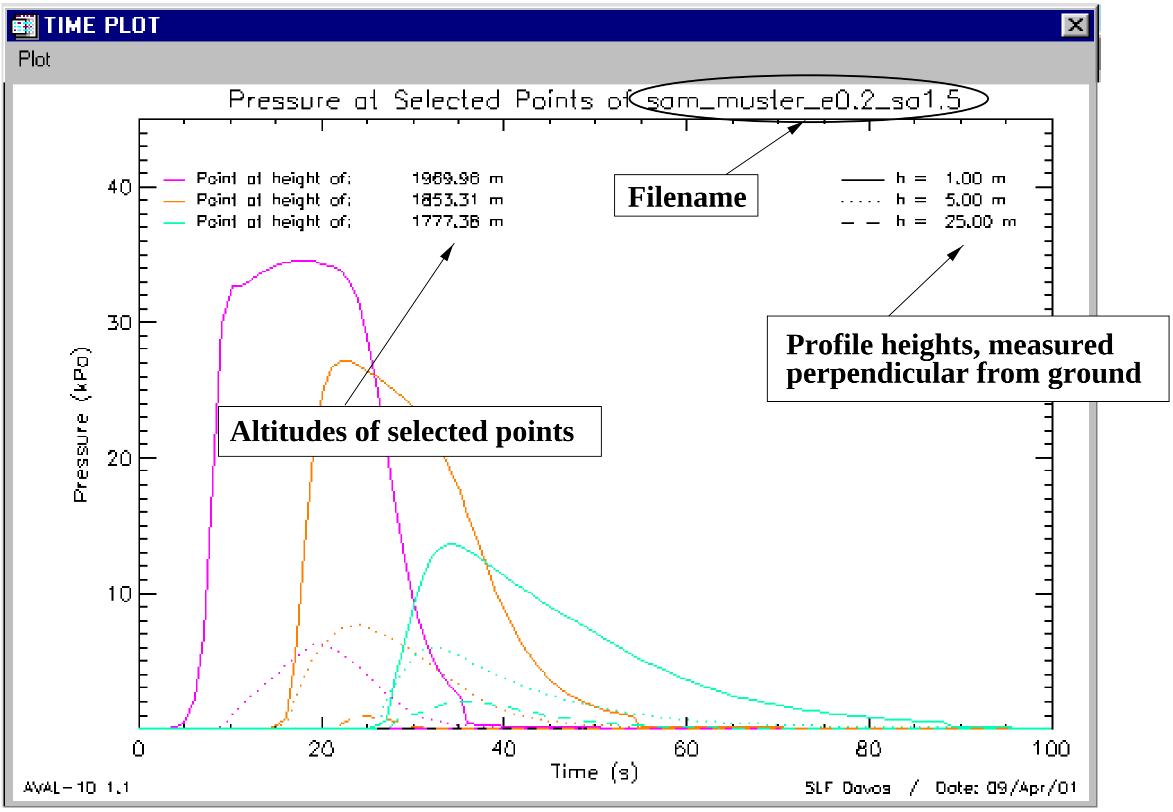


Figure 18: **Time Plot** window in the `POWDER SNOW`-mode. The development of velocity at three points in three heights is shown (1.0, 5.0 and 10.0m).

2.7 Profile Plot - Menu

Profile Plot
- Velocity
- Pressure
- Density

Profile Plot is only available in the POWDER SNOW-mode, because the results of dense flow simulations are constant over the avalanche height, whereas the results of powder snow simulations change over height. It is possible to show the vertical profiles of the maximum reached values during a simulation (of velocity, pressure and density) at user selected points along the topography. The **Profile Plot** is shown in a seperate window (see Figure 19).

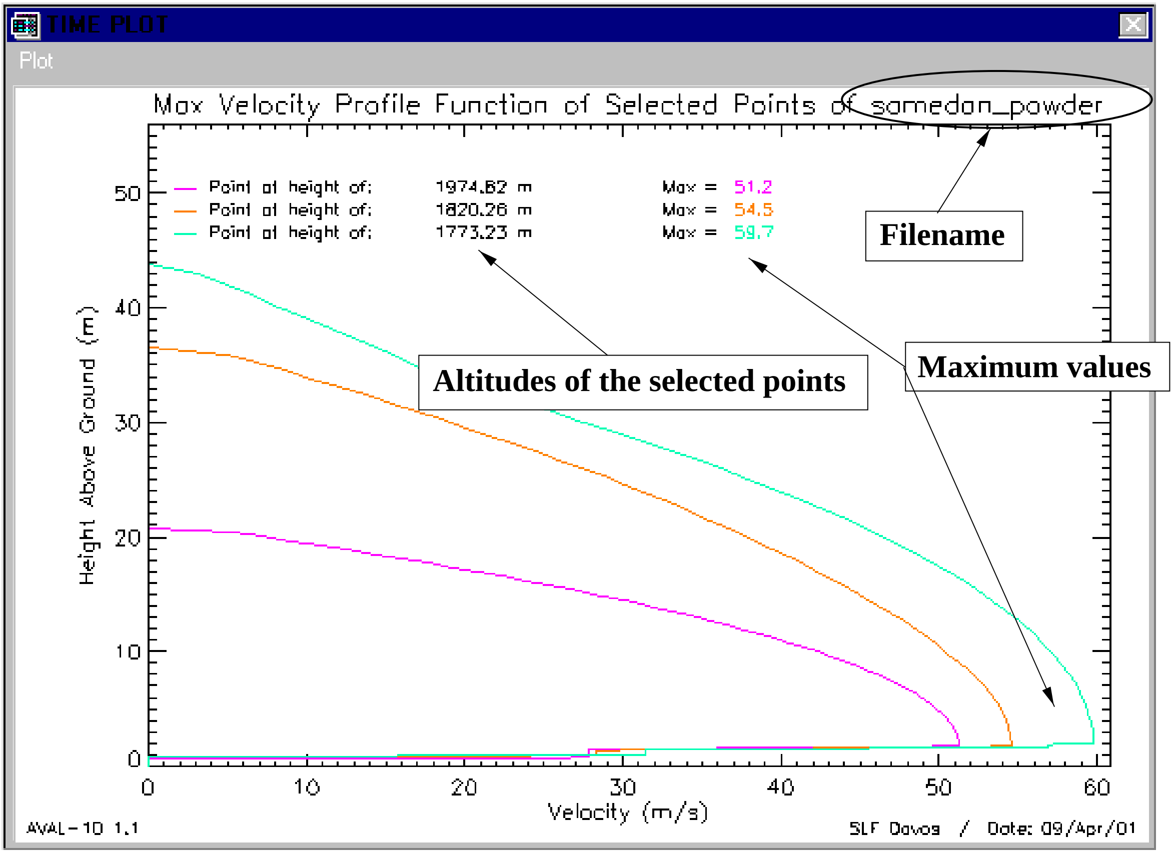


Figure 19: **Profile Plot** window in the POWDER SNOW-mode. The maximum velocity profile is shown in relation to avalanche height at three different points.

The **Change Scaling** dialogue window of **Profile Plot** is shown in Figure 20. It is opened with **Plot** → **Change Scaling**.

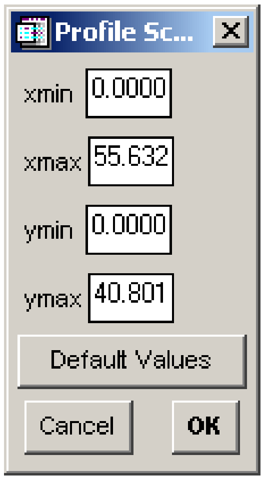


Figure 20: **Change Scaling** dialogue window of **Profile Plot**.

2.8 Points - Menu

Points
- Select with Cursor
- Select manually
- Select Monitoring Points
- Draw / Remove Points
- Draw / Remove Monitoring Points
- Draw / Remove Input Points
- Show Selected Point Info
- Print Selected Point Info

Any points in the topography can be selected here (either with the mouse or by entering the height), and the results at these points can then be observed over time. In the `POWDER SNOW`-mode the vertical profiles of the maximum values attained during the simulation can also be displayed (see Figures 17,18 and 19).

Use **Points** → **Select with Cursor** to mark any points with the mouse. The *left* mouse button is used to select the points and the *right* mouse button is used to end the selection. This function is also available with the right mouse button.

!!! BEWARE !!!
The selection MUST be ended with the right mouse button

Points → **Select manually** allows to reach the following dialogue window:

Now enter the height a.s.l. of a point you wish to select and then either click on **Another Point**, if you wish to select other points or on **Done**, if this was the last point of interest. It is to be noted that points on the opposite slope can also be specified, but that *negative* altitudes must be used.

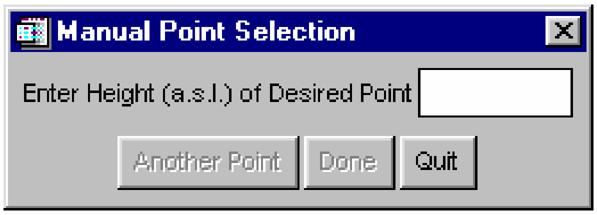
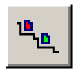


Figure 21: **Points** → **Select manually** dialogue window.

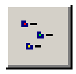
!!! BEWARE !!!
To select points on the opposite slope, use *negative* values (e.g. -1800 m a.s.l.)!!

Points → **Select Monitoring Points** marks directly your Monitoring Points, in case you have specified them. This function is also accesible with the right mouse button.

User selected points can be deleted and redrawn by using **Points** → **Draw/Remove Points**.



Specified monitoring points can be shown and deleted by using **Points** → **Draw/Remove Monitoring Points**.



Use **Points** → **Draw / Remove Input Points** to visualize your input points as red points in a simulation, see Figure 22.

Choose **Points** → **Show Selected Point Info** to get the most important input and output information about a selected point, see Figure 23. This function is also available over the right mouse button (**Show Info**). The information about a selected point can be printed using **Points** → **Print Selected Point Info** .

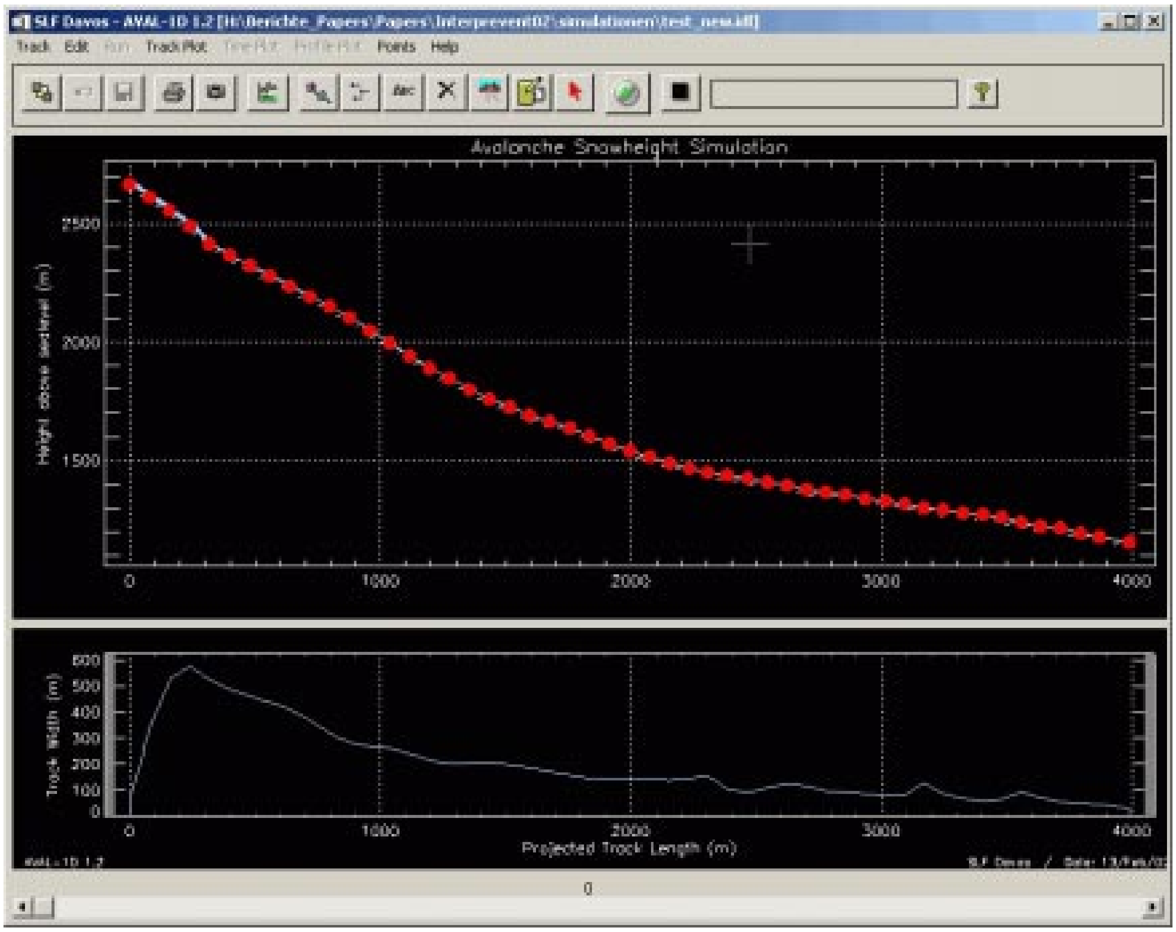


Figure 22: Visualization of input points as red points.

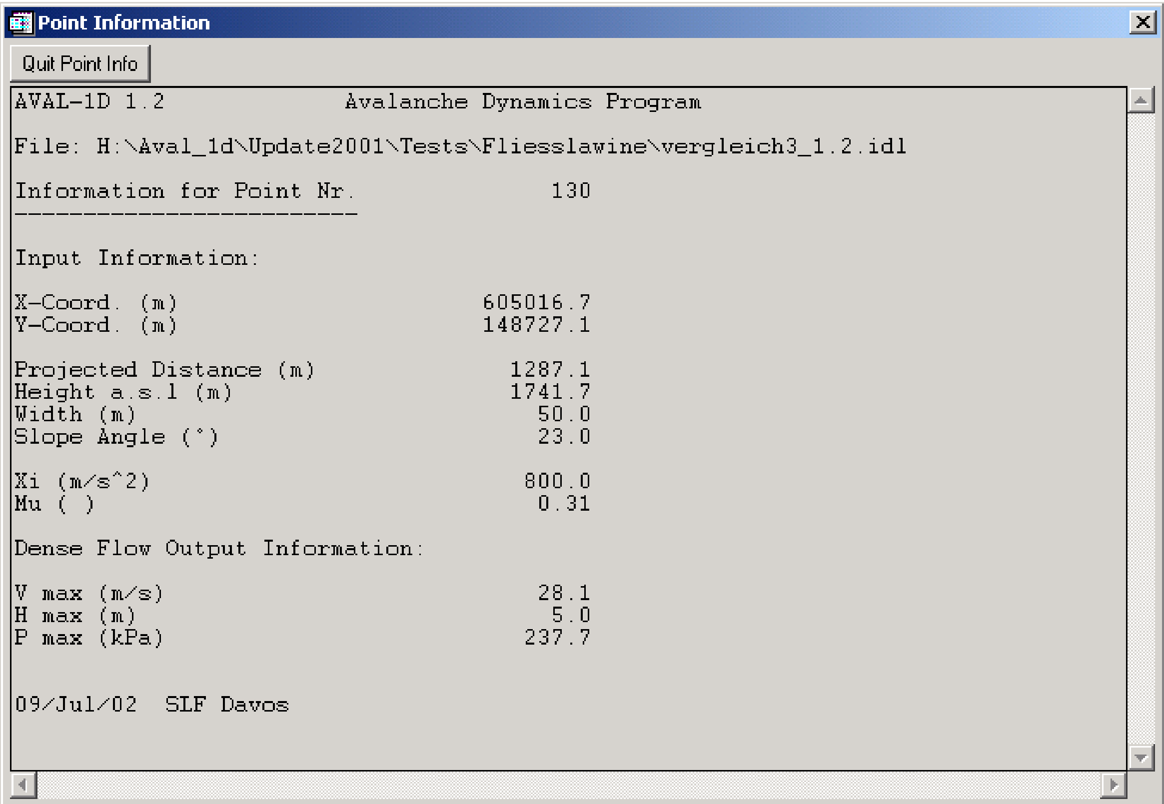


Figure 23: Input and output information about a selected point.

2.9 Toolbar

The structure of the menu is improved and a toolbar created. The most important functions are now accessible with one single mouse-click. If you position the mouse-pointer over a toolbar-button, the text-field on the right explains the function of the button. The appearance of the toolbar changes from Input- to Output-Mode (see Figures 24 and 25).

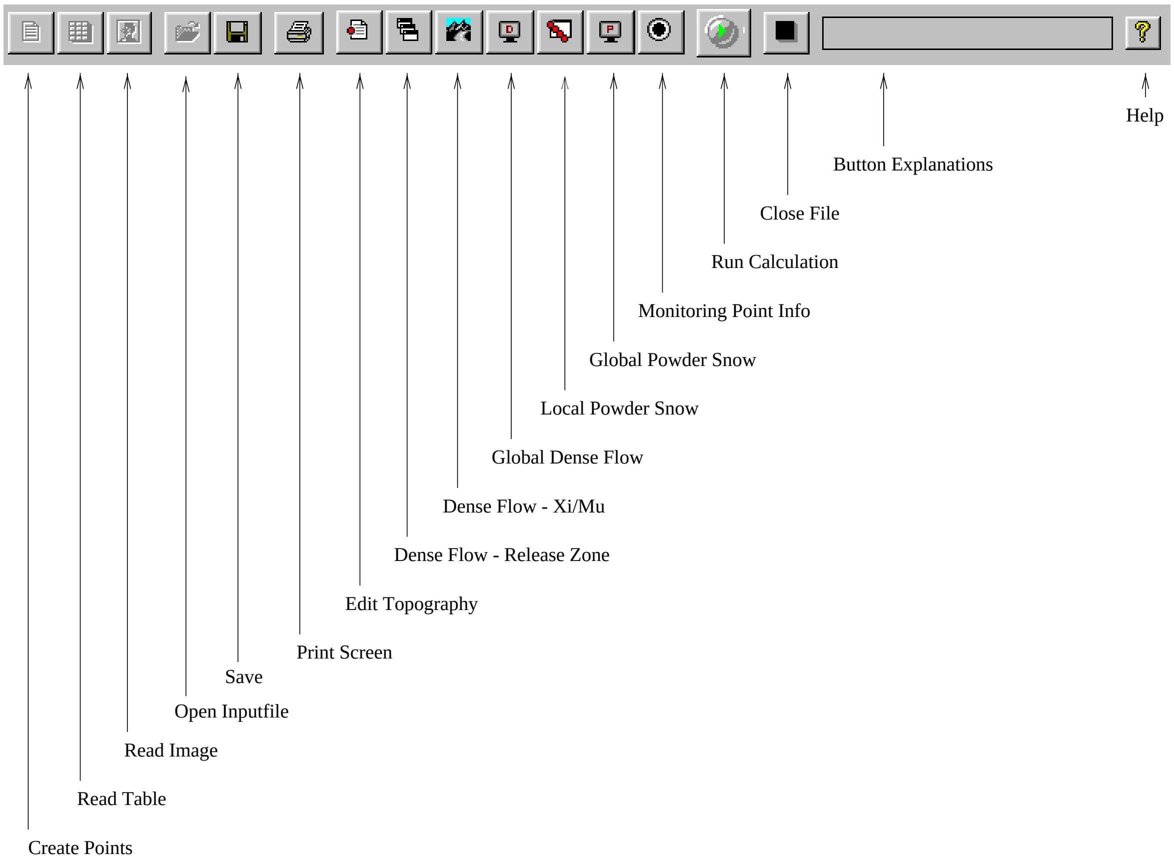


Figure 24: The Input-Toolbar looks like this.

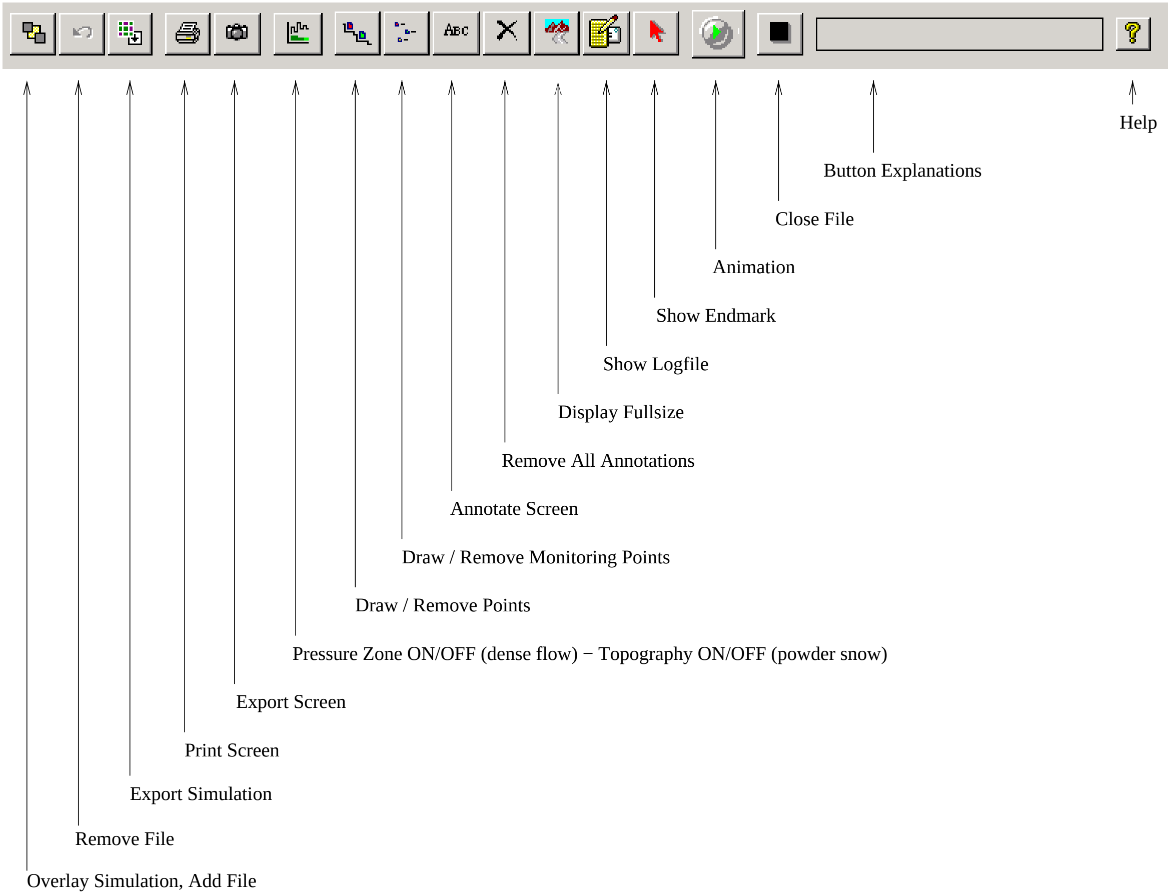


Figure 25: The Output-Toolbar looks like this.

2.10 Use of right mouse button

The right mouse button holds important functions that are not accessible from the toolbar. Pressing the right mouse button in the Input-Mode gives the following menu:

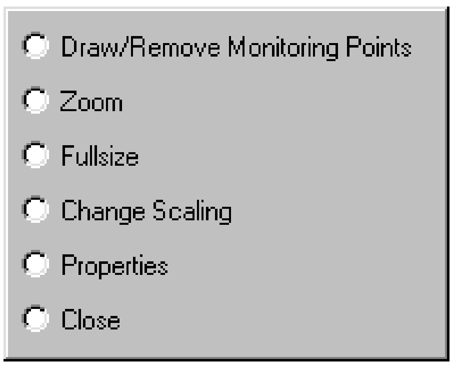


Figure 26: Pressing the right mouse button in the `INPUT` Mode.

DENSE FLOW/POWDER SNOW mode: Pressing the right mouse button in the upper window gives the following menu:

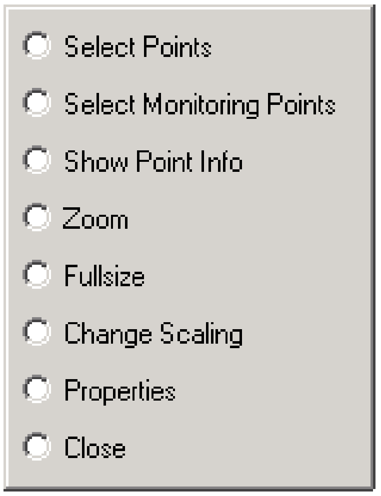


Figure 27: Pressing the right mouse button in the upper window of DENSE FLOW/POWDER SNOW mode.

Additionally, in the POWDER SNOW mode you can press the right mouse button in the lower window and get the following menu:

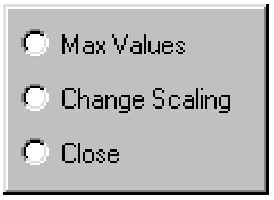


Figure 28: Pressing the right mouse button in the lower window of POWDER SNOW mode.

3 Input mode

Topographies can be created and modified in the `INPUT` mode. Parameters can also be specified and calculations started. When `AVAL-1D` has been started successfully, two menus can be activated:

- **Track** → **New...**: This menu is chosen in order to enter a new topography (see chapter 3.1).
- **Track** → **Open...**: If there are already `INPUT`, `DENSE FLOW` or `POWDER SNOW` files, i.e. files with the endings `'*.ava'`, `'*.idl'` or `'*.idp'`, they can be opened and processed in the menus
  Track → **Open...** → **Input File**
  Track → **Open...** → **Dense Flow Simulation**
  Track → **Open...** → **Powder Snow Simulation**

!!! Note on file endings !!!
`'*.ava'`: `INPUT` files
`'*.idl'`: `DENSE FLOW` files
`'*.idp'`: `POWDER SNOW` files

3.1 Creating a new topography

The procedure of creating a new topography is identical for dense flow and powder snow avalanches. Differences only appear when the avalanche and calculation parameters are specified.

There are three possible methods of entering a new topography:

- Every individual point can be entered manually using a dialogue window (coordinates and heights etc. of the points must be read off a map and written down - see chapter 3.1.1).
- Reading in a table which has for example been established in Excel using map data (see chapter 3.1.2).
- A digital map can be visualised and used to read in the topography (see chapter 3.1.3).

3.1.1 Creating points

Track → **New...** → **Create Points** allows to attain the dialogue field **Please Select a File for Writing** (see Figure 29). Specify a file name first of all (e.g. `example1.ava`), instead of `untitled.ava`.

Then, after the OK button has been clicked, **Edit Topography** appears for the XYZ-coordinates and the avalanche width information (Figure 30). Each point to be specified is characterised by a question mark (?) in the user interface. It is best to start with the highest point on the

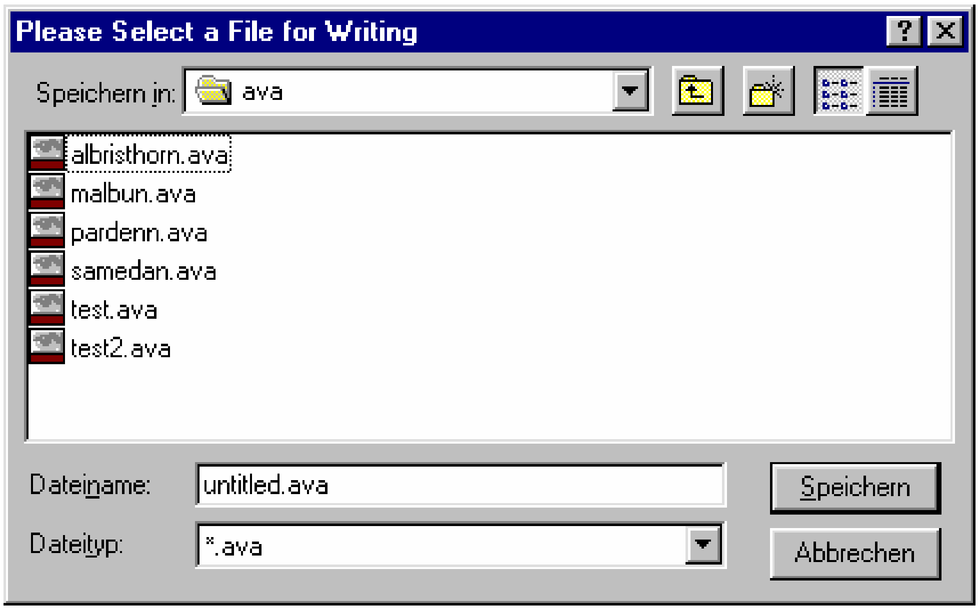


Figure 29: Specification of a file name (*.ava).

profile. X-, Y- and Z- coordinates are required as well as the avalanche widths of the points (all in (m)). Relative distances can be used instead of the x- and y-coordinates (only one entry field is required - the X- or the Y-field).

To make it easier for you, the first field (X-Coordinate (m):) is already marked when you enter the dialogue window. Enter the X-coordinate and press **ENTER**. The cursor will jump into the next field and the field will be automatically marked. Enter now the Y-coordinate and jump to the Z-field and then to the avalanche width (by pressing **ENTER**). After having enterd the first point, click on the **New Right** button above the arrows and enter the next point. Before leaving the dialogue field **Edit Topography** (by clicking on **OK**), each point can be controlled and if necessary modified using the arrows. The last two lines (**Slope above** and **Distance above**) show slope angle and the real distance to the neighbouring point on the left.

!!! BEWARE !!!
Confirm every application with **ENTER**!!

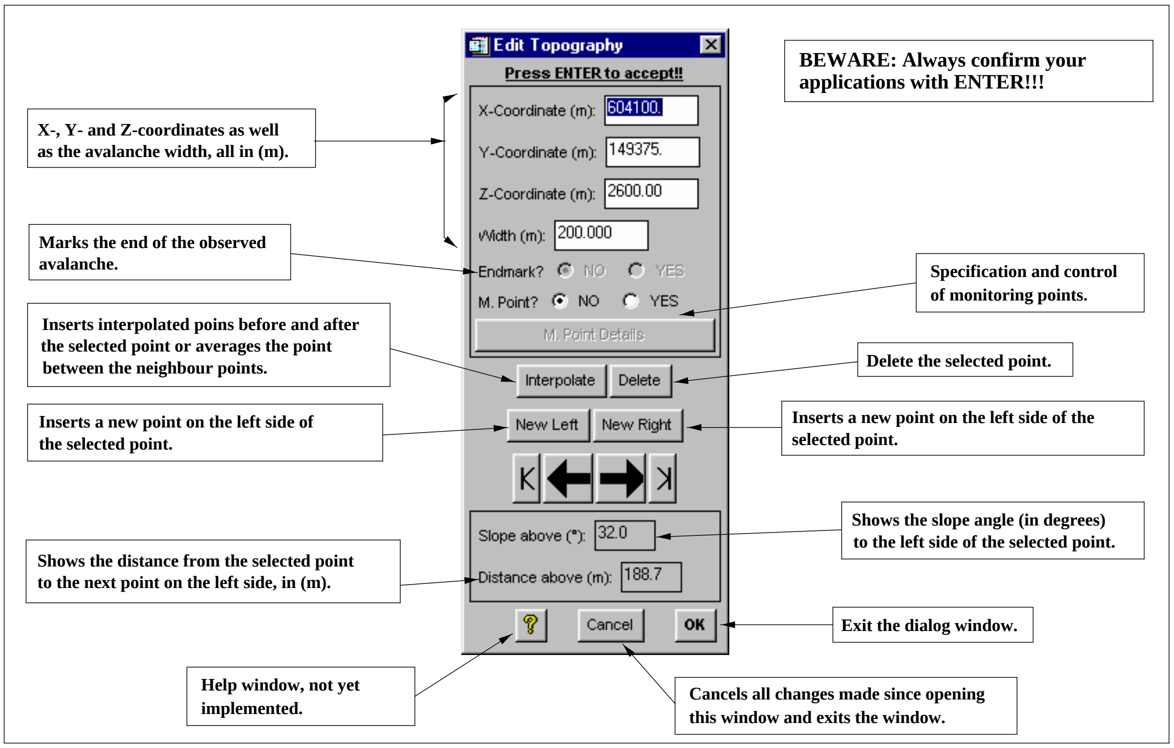


Figure 30: Window for entering xyz-coordinates and avalanche width.

3.1.2 Reading from a table

To read from a table established in an editor, Excel or Word, choose **Track** → **New...** → **Read from Table**. A dialogue window appears, on which the appropriate file must be chosen.

Tables must be configured in the following manner:

Topography:	Samedan		
0.0	0.0	2300.0	120.0
300.0	100.0	2150.0	120.0
500.0	150.0	2000.0	70.0
950.0	200.0	1500.0	100.0
1200.0	400.0	1300.0	100.0
1300.0	500.0	1200.0	100.0

Information about tables:

- The top line **must** contain one of the following words:

  `Topographie:`
  `Topography:`
  `Topografia:`

  so that `AVAL-1D` can recognise the file as a table file. The name of the topography must then be entered, e.g. *Samedan*. This name is then the file name of the input file (e.g. *Samedan.ava*).
- The first column contains the x-coordinates of the points (in (m)).
- The second column contains the y-coordinates of the points (in (m)).
- The third column contains the z-coordinates of the points (in (m)).
- The fourth column contains the estimated avalanche width for every point (in (m)).
- The table **must** have at least two lines of data.
- Negative X-, Y- and Z-values are accepted but not recommended.
- The values can be entered with or without decimal points (`100.0` or `100`).
- The spaces between the values on a line can either be made with the tab or space keys.
- Tables which are made in Excel or Word must be saved as text files (`*.txt`).

3.1.3 Reading from an image

This allows to read from a digital map , to reference with the national map coordinates of any four points and then to choose a topography and read it into `AVAL-1D`.

Track → **New...** → **Read from Image** leads to the menus **Map Images** in Figure 31.

Figure 31: **Track** → **New...** → **Read from Image** menu.

It is now possible to open a graphics file (with **Open Image**), or to **Cancel** in order to return to `AVAL-1D`. Some information on **Map Images**:

- Only the map coordinates are calculated automatically, whereas height a.s.l. is not (no digital terrain model). This means the contour lines must be used and the points must be located exactly on the contour lines.
- Reading from an image requires experienced use of the mouse. Both zooming and selection of topographic points are done with the mouse. Important: *Never double-click!*

Explanation of all the points on the menu:

Open Image: `GIF`-, `TIFF`-, `JPEG`- and `BMP`files can be read. Choose the file you want to process in the dialogue box **Please Select a File**, which appears after clicking on **Open Image**.

Register Image: This is one of the most important functions in image processing. **Register Image** georeferences an image, i.e. a special file is written specifically for the current image (a so-called `world-file`) , allowing to calculate national coordinates from pixel coordinates. Example: if an image called `example.tif` is open, a file called `example.tfw` is made.

Further examples:

- `example.gif` → `example.gfw`
- `example.jpg` → `example.jgw`

- `example.bmp` → `example.bpw`
- `example.tif` → `example.tif`
- `example.tiff` → `example.tiffw`
- `example` → `examplew`

At the end of the referencing process a registration information appears, in which the coordinates given are compared with the calculated ones and the differences are listed. Each individual user must then decide whether the differences can be tolerated or whether the image needs to be referenced again. Once an image has been carefully referenced, the corresponding `world-file` will later be found.

ArcView / ArcInfo use the same `world-files` - i.e. an image which has been referenced in ArcView / ArcInfo can be processed with the corresponding `world-file` in `AVAL-1D`.

Procedure Please read this procedure once, before you reference your first image.

After clicking on **Register Image** a command appears to mark 4 points. The order of the points in Figure 32 is only a suggestion and not obligatory (order and position of the points can be chosen freely!).

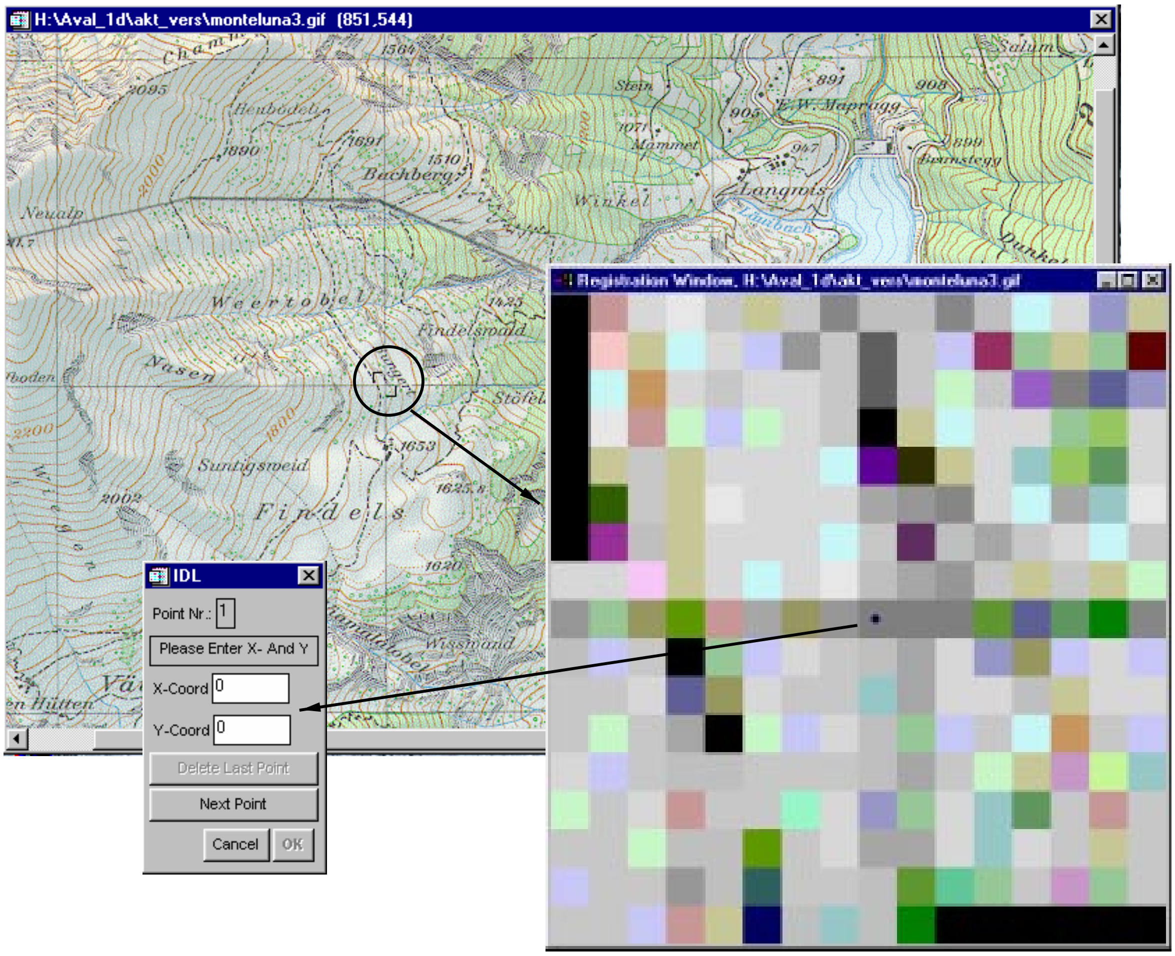


Figure 32: Example of the referencing of a map excerpt.

Each of the 4 points must be zoomed (Figure 32) - i.e. you must click to the left above and to the right below the point with the mouse in order to zoom it. The selected region will then be enlarged in a way that pixels will be visible, see Figure 32, window to the right.

> **!!! BEWARE !!!**
> The zoom area is chosen by clicking *once* to the left above and *once* to the right below a point - *never double-click*!!!

Then mark the point with the mouse (one click with the left mouse button, Figure 32). The dialogue box **Register Image** appears, into which the national x- and y- coordinates must be entered. Press **Next Point** to enter the next point. After the fourth point press **OK** to finish. When all points have been entered, `AVAL-1D` calculates the national coordinates of all points using the pixel coordinates and compares the results with the coordinates you originally entered. This information is displayed automatically in a window. You must then decide whether the image has been referenced precisely enough or whether the procedure needs to be repeated.

> **!!! BEWARE !!!**
> You alone need to make this decision! `AVAL-1D` will write the transformation file (`world-file`), no matter whether the differences are big or small!

Create Topography: This is only possible if an image has been referenced, i.e. if `AVAL-1D` can find the corresponding `world-file`. If not, **Register Image** must be effected first.

Figure 33 appears after selecting **Create Topography**.

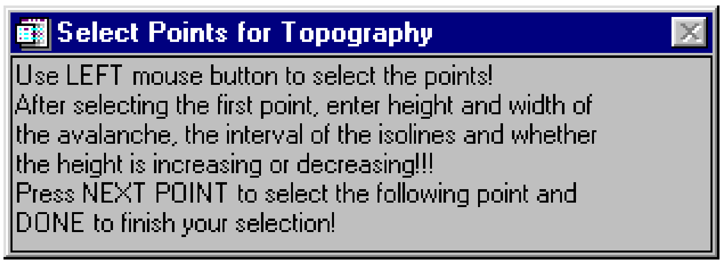


Figure 33: Information on **Create Topography**.

Important information:

- The points must be selected with the left mouse button (*never double-click!*). After a point has been chosen, the dialogue window in Figure 34 appears.
- The altitude of the first point must be entered in the box **Height above sea level (m):**. Indicate the distance between the contour lines you want to follow in the box **Isoline interval (m):**.
- `AVAL-1D` assumes that you will start with the highest point. You can of course start with the lowest point, but must then click on the **+** button in **Slope :** as height then increases (the same must be done for opposite slopes).

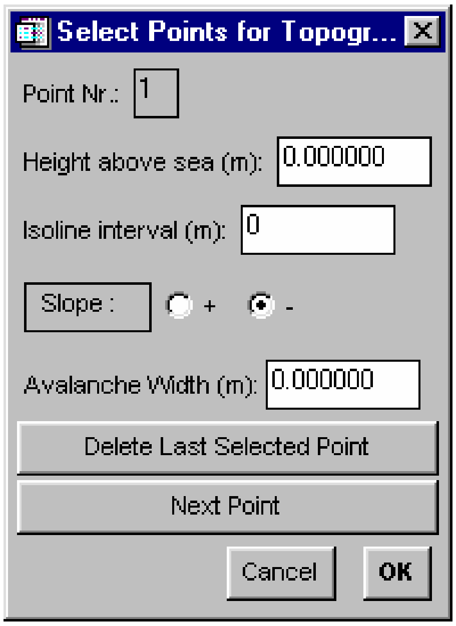


Figure 34: **Create Topography** dialogue window.

- The estimated width of the avalanche can be entered in **Avalanche Width (m)**:; this is not obligatory (the avalanche width can also be entered later in the `AVAL-1D` user interface).
- **Delete Last Selected Point** removes the last point selected.
- Click on **Next Point**, to be able to mark the next point.
- **OK** ends **Create Topography**. If you entered wrong points, you can cancel the application with **Cancel**.

Reload Original Image: This is useful if the wrong area was enlarged by zooming and you need to select it again.

Zoom Image: At present an image can only be enlarged but not made smaller again. The upper left and lower right corners must be selected with the mouse. `AVAL-1D` then enlarges the selected area by a factor 2, i.e. doubles it. A zoomed area can be enlarged further, as already mentionned, but cannot be made smaller again. **Reload Original Image**, creates the original image again.

Print Image: The image can be printed here (with or without topographical points). The points are black.

Close Image: The current image is closed, and a new image can be opened with **Open Image**.

Cancel: This allows you to return to the `AVAL-1D` user interface without having read in a topography.

Show Topography: This only becomes active when a topography has been specified successfully (at least two points have been selected). The dialogue window **Map Images** is closed and the topography is shown in the user interface.

3.2 Opening an existing topography

Track → **Open** → **Input File** leads to the dialogue box **Select AVAL-1D Input File** (see Figure 35). The (`*.ava`) filter shows all files which can be read. Select a file with the mouse and then

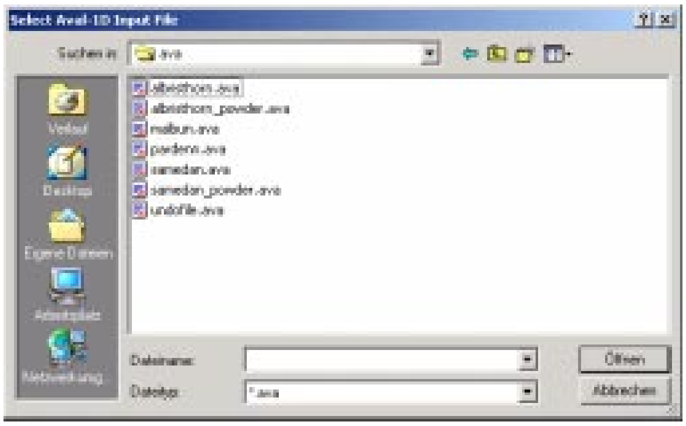


Figure 35: Dialogue window **Select AVAL-1D Input File**, to open a file.

click on 'OK' (see appendix A.1, p. 91).

3.3 Modifying the topography

In the menu **Edit** choose **Edit** → **Topography** to get into the dialogue box **Edit Topography** (see Figure 36). The arrows allow to jump from point to point, and if required, the X-, Y- and Z-values as well as the avalanche width can be modified directly (see appendix A.2, p. 94).

Endmark allows to mark the end of the avalanche in order to be able to compare it later with the calculated run-out area.

The **Interpolate** button contains two functions (see Figure 37):

- With **Interpolate** an additional point can be entered either to the left, to the right or on both sides of a chosen point. To do this, press on **left**, **right** or **both**. Use **Rel. Distance** or **Height a.s.l.** to insert the point. The value **Rel. Distance** indicates the relative distance between the additional point and the original point. With **Height a.s.l.** it is possible to directly specify the altitude of the point. **Interpolate** is mainly used for the calculation of powder snow avalanches. `AVAL-1D` smooths the topography from point to point before starting a calculation. If the topography is complicated (with steep drops etc.) the smoothed curve (spline) may not follow the topography. The spline can be improved by adding more points. To do this, use the arrows to go to the point where the difference is greatest, press **Interpolate** and add a point to the left and / or right.

- **Average** can be used to average the selected point with the points located to the left and right of it. If this function is chosen, **left/right/both** and **Rel. Distance** are no longer active.

To specify a monitoring point, choose **Edit Topography**, jump to the topography-point you want to set a monitoring point (with the arrows) and press **YES** at **M. Point ?**. A dialogue

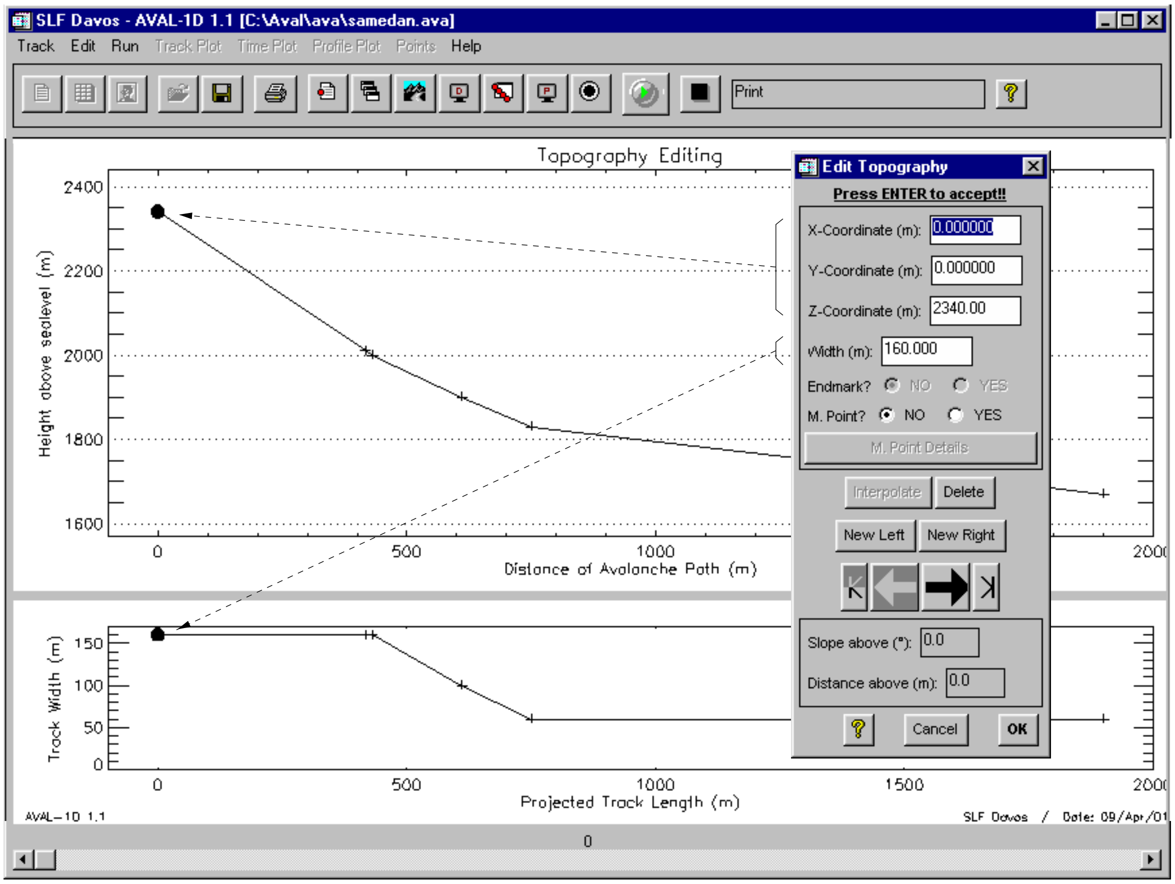


Figure 36: XYZ-dialogue window **Edit Topography**.

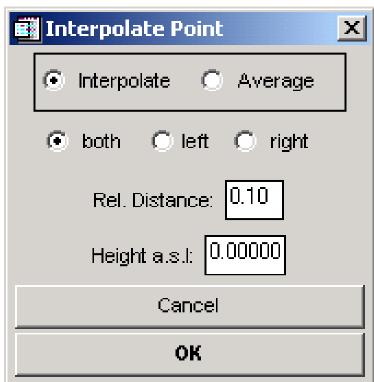


Figure 37: **Interpolate** dialogue box

window appears (Monitoring Point Info, see Figure 39, dialogue window on the right) where a name must be specified. Observed flowheights and flowvelocities can be specified as well, but not necessarily.

The results of these points (flowheight and flowvelocity) will be written in a log file (together with general information such as chosen parameters, runout distances, etc.) and compared to the observed values (if specified). The log file can then be opened or printed out directly from within `AVAL-1D` (**Track Plot** → **Show Logfile** bzw. **Track Plot** → **Print Logfile**), see

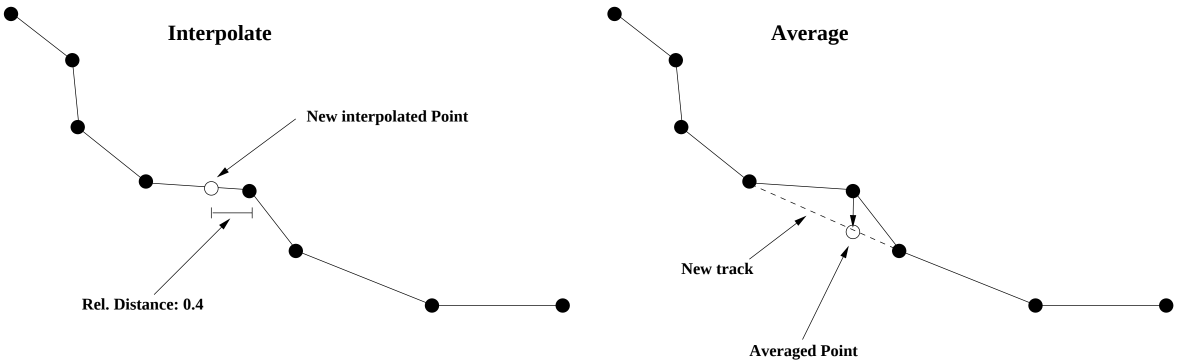


Figure 38: Graphical explanation of interpolate functions.

chapter 6.3, p. 79 about log file details.

The **Monitoring Points** are saved in the `INPUT`-file, i.e. when the same `INPUT`-file is opened again later in order to calculate a similar simulation, the same **Monitoring Points** are available.

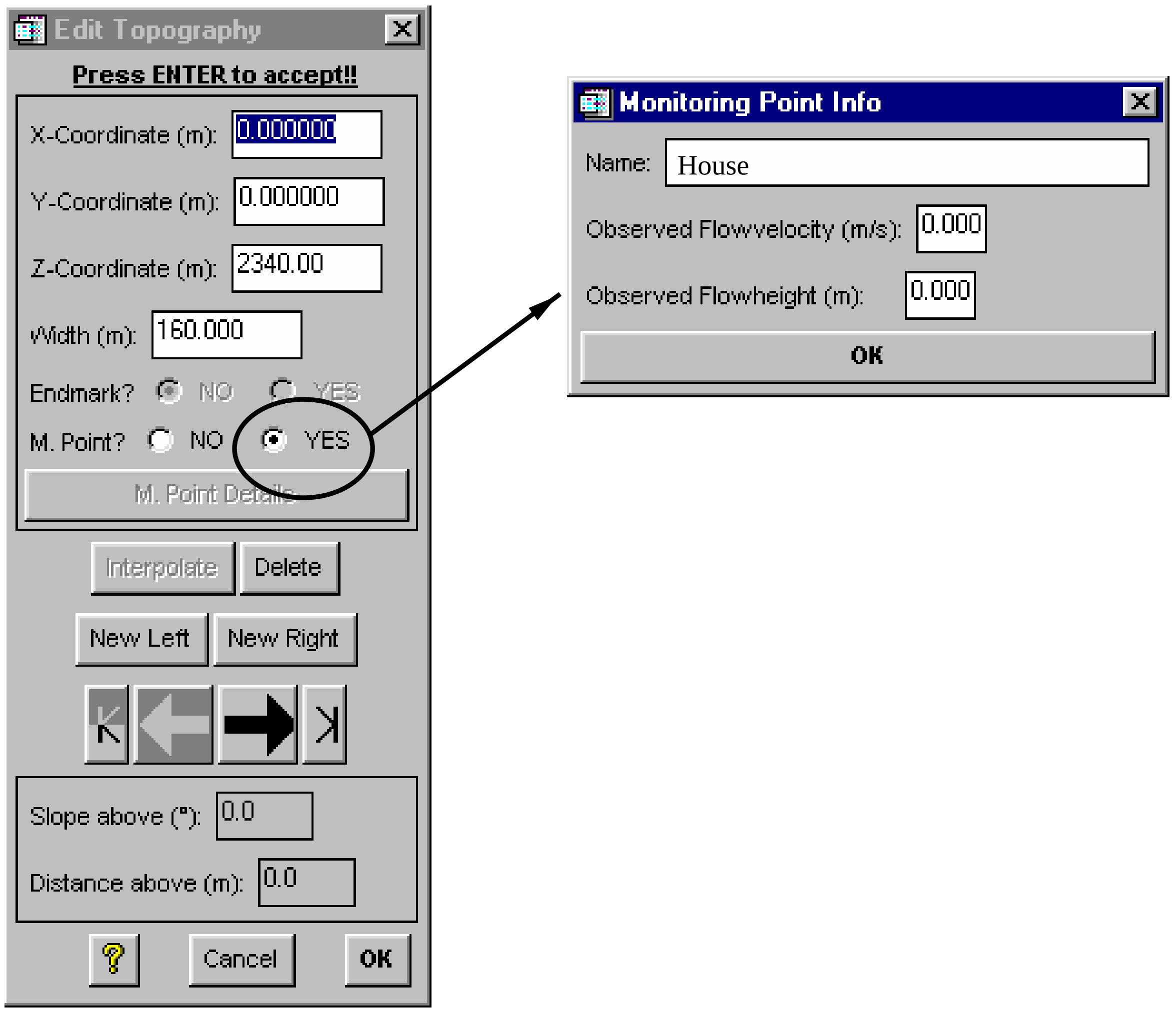
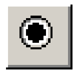


Figure 39: Enter monitoring points.

You can get information about the monitoring points by choosing **Edit** → **Monitoring Point Info** or clicking the **Monitoring Point** Info-Button.



3.4 Specification of the parameters

The model parameters must be entered before a calculation can be started (for each topography element). On the one hand there are dense flow and powder snow avalanche parameters and on the other there are avalanche and calculation parameters. Depending on avalanche type, the avalanche parameters include:

- **Dense flow avalanches** - Friction parameters and snow height.
- **Powder snow avalanches** - Height of the saltation layer, density of the saltation layer or height of the erodable snow layer.

The calculation parameters include for example the time step, the total simulation time, the density ρ and internal friction λ.

3.4.1 Avalanche Parameters...

In order to enter the avalanche parameters, select **Edit** → **Avalanche Parameters...** and then

- **Dense Flow - Release Zone**,
- **Dense Flow - Xi/Mu**
- or **Powder Snow**,

depending on whether you want to calculate a dense flow or a powder snow avalanche.

Dense Flow - Release Zone: The release zone of a dense flow avalanche can be specified by pressing **Edit** → **Avalanche Parameters...** → **Dense Flow - Release Zone**. In the upper part of the dialogue window (**Specify Release Snowheight:**) the release snowheight can be entered. Below, you can always check your release volume and mass. The release mass is of course dependened on the density, which can be changed here.

If your information about the avalanche width is rather vague, but you know more or less the release volume of the dense flow avalanche, do the following: Press **Yes** at **Use Release Volume?** and enter your release volume at **Total Release Volume (m^3):**. `AVAL-1D` calculates then the appropriate avalanche width for the release zone (constant width throughout the zone). Normally, this function is disabled, read chapter 6.2, p. 76 on how to enable this funtion.

There is a significant difference with the analytical Voellmy-Salm model in the determination of the length of the fracture zone. In the numerical model the following must be respected:

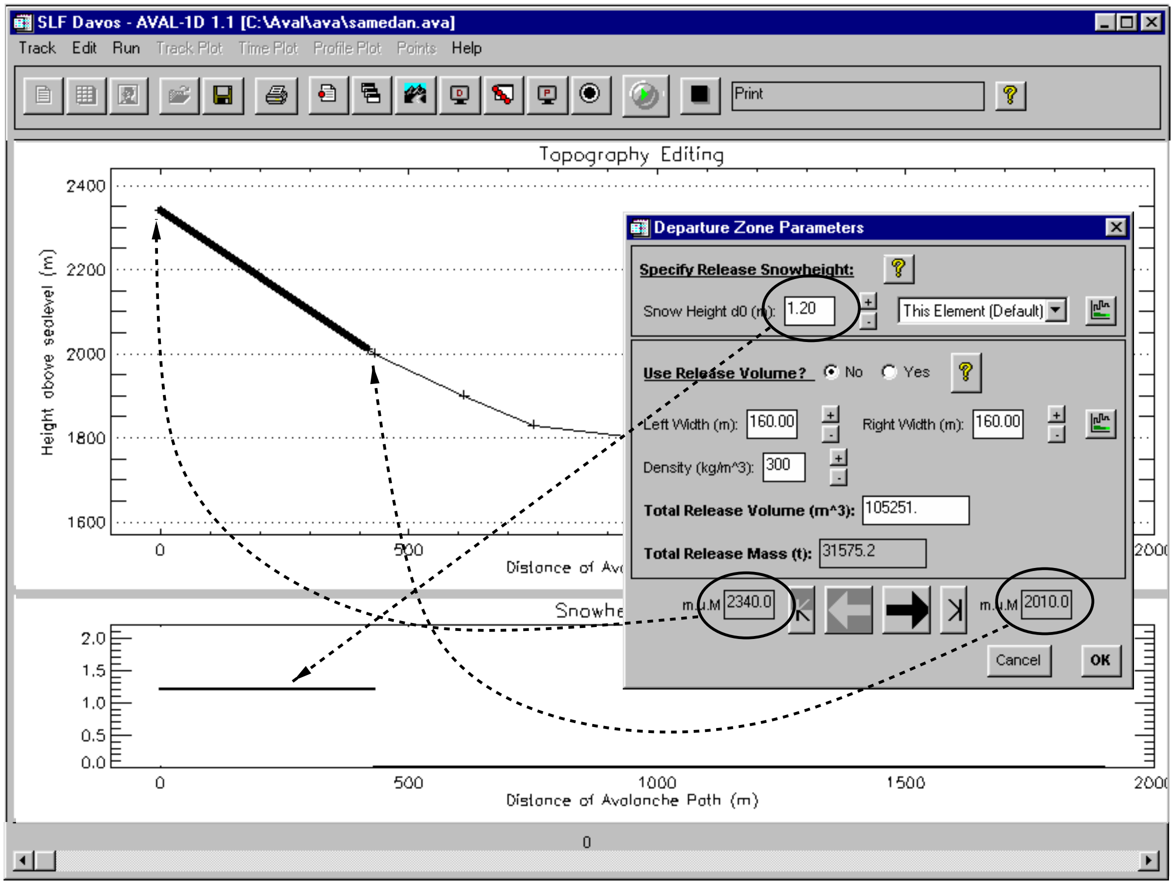


Figure 40: **Dense Flow - Release Zone** dialogue window. Here the release zone is specified.

Attention: In the numerical model `FL-1D` the sum of the horizontal lengths of the specified fracture zones must not be more than 500m.

The reason for this limitation is: in both the analytic Voellmy-Salm model and in the numerical model, the mass entrainment in the avalanche track is not at all considered. The principle is based on the concept of having a fracture area and then making the avalanche flow down over snow free terrain. The calibration of the friction parameters is based on this assumption. The Voellmy-Salm model is based on the flow amount whereas the `FL-1D` model is based on avalanche mass. In the analytic model a very long fracture zone does not lead to an increase in flow amount, but in the `FL-1D` model a long fracture zone would lead to an increase in mass and therefore also to higher velocities and greater runout distances. In order to obtain comparable results it is necessary to limit the length of the fracture zone to 500 m in the numerical model.

Dense Flow - Xi/Mu:

- ξ (m / s^2) (Turbulent friction factor „Xi“),
- μ ( ) (Dry friction factor „Mu“),

ξ and μ are of importance for the whole avalanche track. The significance of ξ and μ is explained in the manual for dense flow avalanches, part 5.3, p. 8. The default values for a 300-year, large scale avalanche at over 1500m.a.s.l. are (ξ = 2500 m/s^2, μ = 0.16). AVAL-1D provides you with proposed values which the SLF would choose for ξ and μ, according to your topography, return period and track style (red line in the lower window, entitled as **SLF-Proposal**). Choose **Use SLF-Proposal** to overtake these values. These proposals are without guarantee; if you find an error, please report it to us.

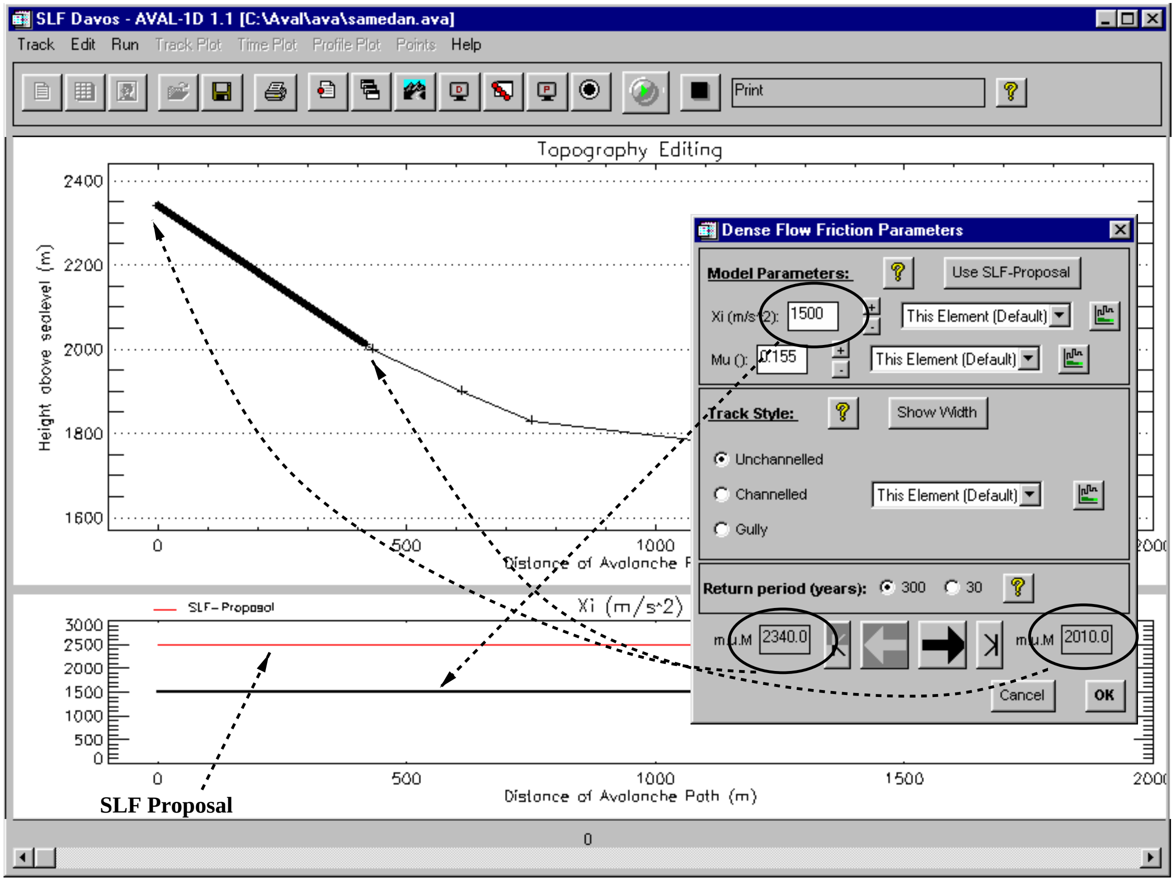


Figure 41: **Dense Flow - Xi/Mu** dialogue window. Choice of friction parameters.

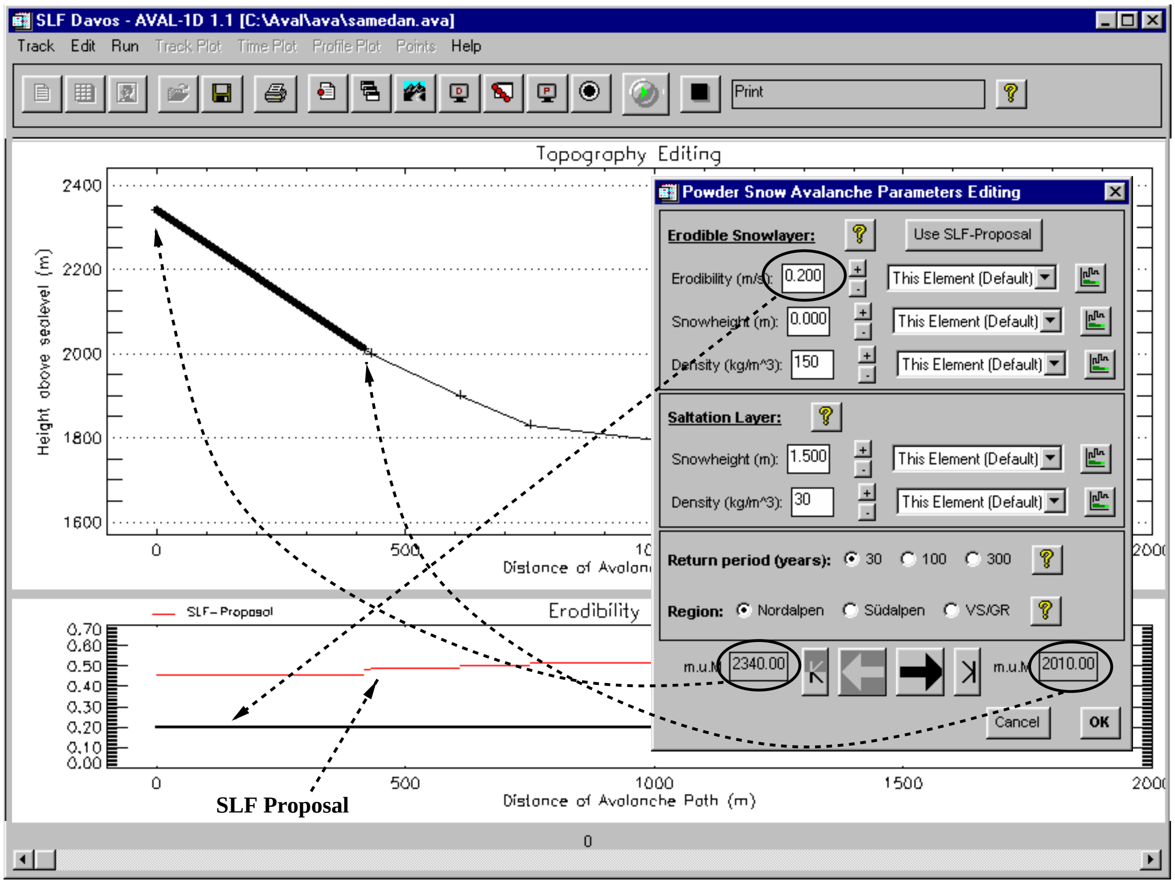


Figure 42: **Powder Snow Parameters Editing** dialogue window.

Powder Snow: Figure 42 shows the dialogue box **Powder Snow Avalanche Parameters Editing**. These parameters can be edited there:

- Erodibility (m / s) (e),
- Snowheight (m) (Height of Erodible Snow h1),
- Density of Erodible Snow (kg / m^3) (d1),
- Snowheight d0 (m) (Height of Saltation Layer h2),
- Density of Saltation Layer (kg / m^3) (d2),
- Suspension Rate (0-1): (s)
- Return Period (years):
- Region:

More parameters will be displayed, if you activate the check box **Show All Powder Snow Parameters** at **Track** → **Properties**. Anyway we suggest not to do so, because in most cases, you won't need the last four parameters.

3.4.2 Calculation Parameters

Calculation parameters are parameters which apply to the whole calculation, such as time-step, end time, and calculation-specific parameters. The simulation can also be given a (**Name**) and detailed information about the background of the calculation can be found in (**Info**). Dense flow and powder snow avalanches are also differenciated here. In the menu **Edit** → **Calculation Parameters...** either **Dense Flow** or **Powder Snow** can be selected:

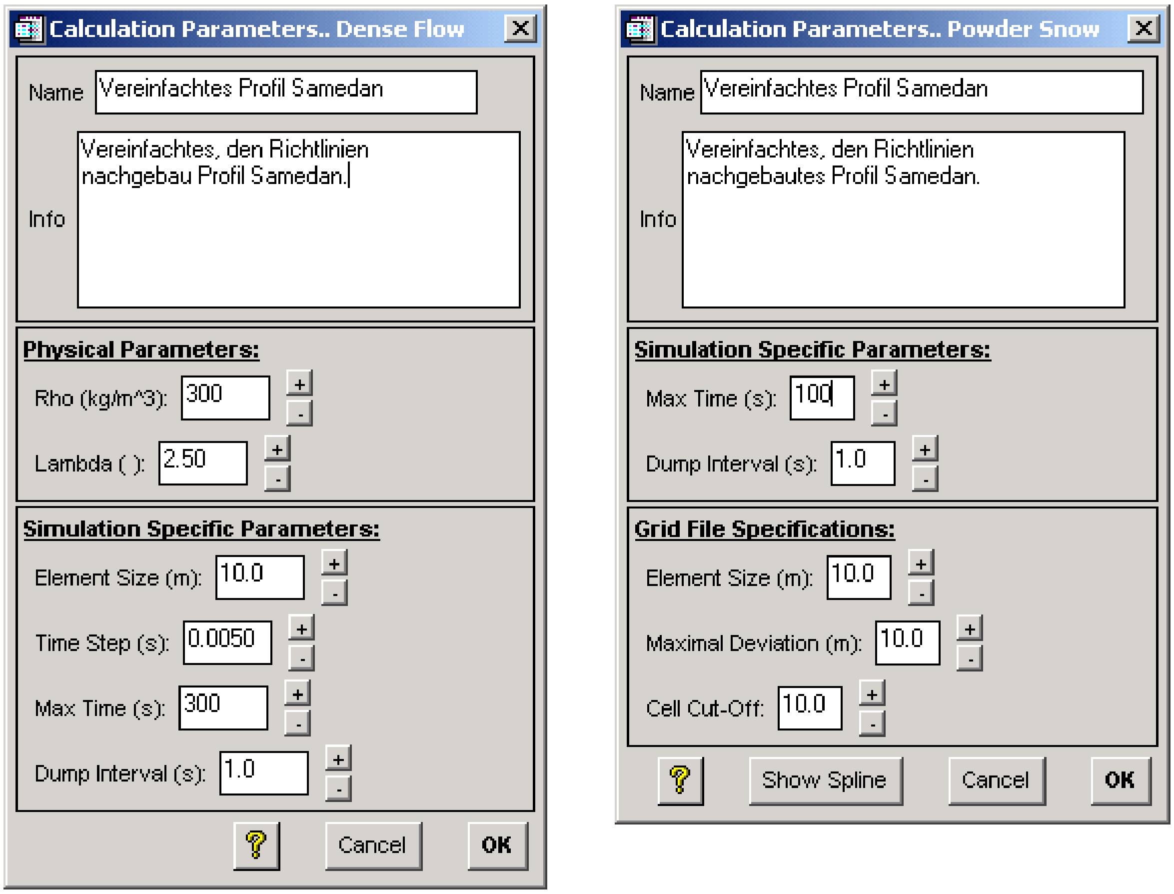


Figure 43: **Dense Flow and Powder Snow** calculation parameters

- Dense Flow:

  Figure 43 (a) shows the dialogue box **Dense Snow Global Parameter Editing**. The following global parameters can be edited:

  Rho & Lambda: The density ρ (**Rho (kg/m^3)**) and the internal friction λ (**Lambda ( )**) can be specified. They are constant for all elements along the avalanche track. These parameters should not be modified and the default values - see Tabelle 1 should be maintained.

  Element Size & Time Step: The most important parameters determining the simulation numerics can be established in this menu. These are the **Element Size (m)** and **Time Step (s)**. In most cases, these numerical parameters do not need to be modified and can be left in their default settings. (see table 1).

Max Time: Another parameter driving the calculation is the maximum time **Max Time (s)**. The calculation of the avalanche is interrupted after this time span. The default setting for this time is 300 s. In most cases, this is enough. It should however be increased for particularly long avalanche tracks.

Dump Interval: The interval at which the simulation results are recorded for later visualisation is the **Dump Interval**. Usually this occurs at an interval of one second. This then allows to visualise easily how far the avalanche has progressed because one step corresponds to one second. The smaller the interval, the greater the amounts of data to be recorded. It is recommended to use an interval of 2 seconds for large avalanches progressing for up to 300 s. This parameter does not have any influence on the stability of the numerical calulation.

Table 1: Default values of the friction parameters (which are constant over the entire length of the avalanche track) and of the simulation parameters (`DENSE FLOW`)

Parameters	Description	Default value
Name	Avalanche name	$<$ none $>$
Info	Additional information about the simulation	$<$ none $>$
Rho ρ	Density (kg / m^3)	300
Lambda λ	Internal friction ( )	2.5
Element Size	Size of a calculation element (m)	10
Time Step	Time step (s)	0.005
Max Time	Maximum time of calculation (s)	300.0
Dump Interval	Time interval for visualisation of results (s)	1.0

- Powder Snow:

Figure 43(b) shows the dialogue window **Powder Snow Global Parameter Editing** (see also chapters A.3 and A.4). The following five parameters should be set for powder avalanche calculations:

Max Time: Duration of the simulated avalanche. Values between 50 and 200 should be used, depending on the length of the avalanche track and the size of the avalanche. The simulation stops as soon as **Max Time** is reached.

Contrary to `FL-1D`, `SL-1D` selects the time step length Δt autonomously within a given range. If Δt sinks below 1 ms (in version 0.5.11), this is an indication of numerical instability and the calculation is interrupted.

The calculation time necessary for a simulation is approximately proportional to **Max Time**. It is enough to make the simulation last a few seconds longer than the time when the snout of the avalanche reaches the furthest point of interest. The evolution of pressure at this point (**Time Plot** $\rightarrow$ **Pressure**) allows to check whether the maximum time has been passed or not. When the topography includes the opposite slope there are often instabilities in `SL-1D 0.5.11` if the **Max Time** is too long.

Dump Interval: The values of all terrain variables (d. h. h_1, h_2, u_2, ρ_2, h_3, u_3, ρ_3, k und ϵ) are recorded in the output file for every grid point as soon as the simulated time has reached or surpassed the values $n \cdot \Delta t_{\text{dump}}$ with $n = 0, 1, 2, \ldots$.

The size of the output file (and the memory and time required for the graphic presentation of the results) is inversely proportional to **Dump interval**. Too long intervals can however lead, for example, to pressure maxima not being registered at a particular point. For this reason, values of 1–2 s should be used for trial simulations whereas intervals of 0.5–1 s should be chosen for final simulations.

Element Size: The mesh size Δx of the calculation grid influences the simulations in various manners. The quality of the numerical approximation increases with decreasing element size. A good convergence of the results is obtained with $\Delta x <$ 5–10 m. Element sizes which are significantly greater than 10 m induce maximum pressures which are up to 50 % too small.

It should be noted that a maximum amount of 2048 grid points is programmed in `SL-1D 0.5.11`. It is therefore advisable to choose $\Delta x > L/1500$, where L is the distance on the map between the first and the last point.

The memory required on the disc and in the RAM is inversely proportional to Δx, but the RAM is hardly ever a problem. Typical simulations produce output files of 0.5 to 10 MB. As the length of the time step is also inversely proportional to Δx, the calculation time is quadrupled when the element size is halved.

Maximal Deviation: The polygon defined by the selected points is smoothed to obtain more realistic curves, which are also easier to calculate. The corners of the polygon are „cut off“, and the modified track no longer goes exactly through the selected points. **Maximal Deviation** determines how far the smoothed curve can deviated from the selected points. It is advisable to choose values between 5 and 10 m. Lower values can be used for very smooth topographies whereas higher values can improve the stability of the simulation for tracks with abrupt changes of slope angle and direction. The smoothed track and the angle of the track can be visualised using **Edit** → **Calculation Parameters...**→ **Show Spline** (see Figure 44).

Cell Cut-Off: `SL-1D` disables calculation cells in which the mass and impulsion flow has dropped below a given value - both in the saltation layer and the suspension layer - at the end of the avalanche after each calculation step. Further grid points are constantly activated in front of the avalanche snout accordingly. This value can be selected using **Cell Cut-Off**.

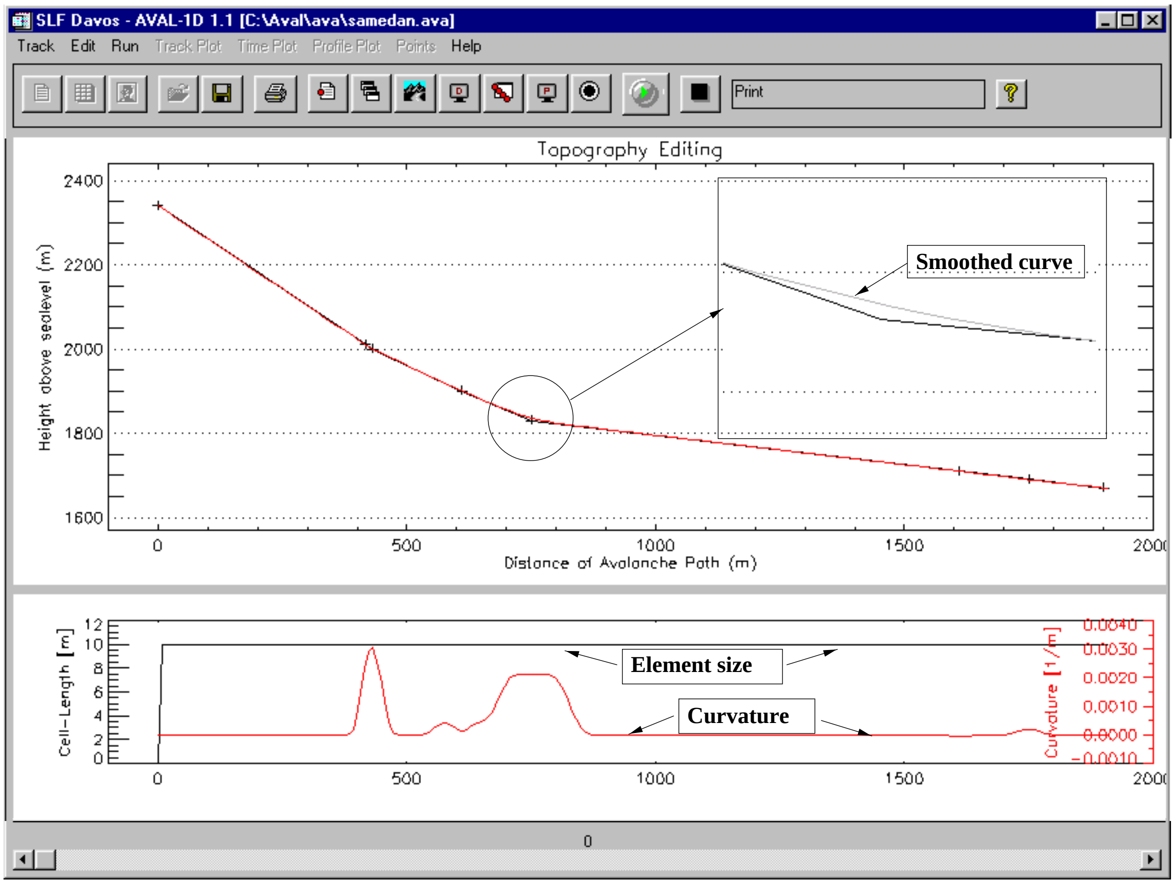


Figure 44: **Show Spline** places the smoothed curve over the topography. Element sizes and curvature are shown in the parameter window.

3.5 Starting a simulation

The simulation is started using the menu point **Run** → **Dense Flow Simulation** or **Run** → **Powder Snow Simulation** (or use the appropriate toolbar button). The name of the topography and the information which was entered in **Edit** → **Calculaton Parameters...** in part 3.4.2 appear. These fields can also be modified at this point. Before the simulation can be started, the name of the (**Output File**) must be specified. This name should contain information about the avalanche track and about the characteristics of the simulation - e.g. frequency of occurrence, parameters, grid or element size. For powder snow avalanches, the current simulation can be characterised in detail using **Run Name**. This line is used as a caption for the plots.

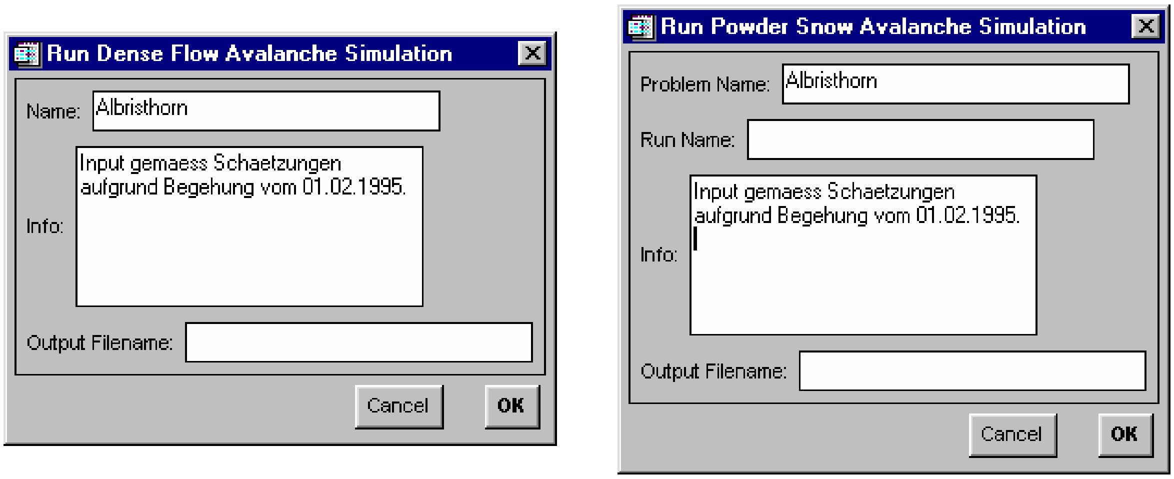


Figure 45: Dialogue windows if a simulation was started.

Note: When a simulation is started, a new input file is automatically saved with the same name as the results file (with the ending `*.ava`). This implies that the user does not need to save the input file before the calculation.

After the calculation has started, the evolution of the simulation can be observed in a DOS window. In `FL-1D` the most important values (current flow height and velocity, maximum flow height and velocity, current mass flow, numerical errors in the conservation of mass and the specified observation points) appear on the screen and are written into a log file (`*.dlg`) for every **Dump Interval**. `SL-1D` gives the time, the time step length, current activated cells and further information for each time step and these are also recorded in a log file (`*.plg`).

The simulation stops when the specified simulation time (**Max Time**) has been attained. The detailed results, i.e. the values of all field variables at the **Dump Interval** specified in **Edit** → **Global Parameters** → **Dense Flow** or **Powder Snow** are saved in the file `*.idl` (`FL-1D`) or `*.idp` (`SL-1D`). These files are automatically shown when the simulation is finished (see appendix A.6, p. 104). The simulation is interrupted before **Max Time** if:

- `FL-1D`: the current mass flow is smaller than 0.04 % of the total amount of snow.
- `SL-1D`: if the length of the time steps drops below 1 ms, as this is interpreted as being a sign of numerical instability. The chapter entitled **FAQ** indicates what is to be done in such situations.

Comment: A simulation with the name `sam30j5m` (in the **Output File** window) creates three files:

- `sam30j5m.ava` → Input file, from which the calculation was started.
- `sam30j5m.idp` or `sam30j5m.idl` → the results file.
- `sam30j5m.plg` or `sam30j5m.dlg` → Log file

4 Choice of numerically relevant parameters

4.1 Dense flow avalanches

Element Size: This parameter is the size of a calculation element. The smaller the element size, the finer the spatial resolution of the results. If an element size of 1 m is chosen for example, the model calculates flow height and velocity for all points at 1 m intervals and indications with „one metre precision“ can then be made. If the element size is small enough, there is no significant difference in the simulation results if the element size is reduced even further (i.e. the simulation results converge). For dense flow avalanches, a reduction of the element size has the effect of increasing the flow velocity and increases the runout distance accordingly. If very small elements are selected, the avalanche snow at the end of the avalanche flows into the valley in thrusts. For large avalanches with maximum velocities between 40 and 50m / s it is apparent that the results start to converge when element size is just below 20 m. A standard value of 10 m has therefore been programmed. The maximum velocity generally changes less than 1m / s if the element size is halved here. Element sizes larger than this standard size should not be selected, as there is then the danger of the runout area being underestimated. For large avalanches, the element size should however not be smaller than 10 m because – particularly when slope angle is critical in the runout area ($\tan \mu = \psi$) – the slightly higher velocities can lead to a significant increase in length of the runout area. The calibration of the friction parameters for large avalanche events is set to an element size of 10 m. An element size of 10 m for avalanches which are often longer than one kilometre longis a realistic maximum resolution as smaller element sizes only give a false sense of precision. The sensitivity of the runout distance to element size is much less marked for small avalanches. Element sizes between 10 and 2.5 m can therefore easily be chosen. A standard value of 5 m for small avalanches is recommended. This value is a realistic maximum resolution for small avalanches.

Standard value „Element Size“ large avalanches: 10m (do not modify)
Standard value „Element Size“ small avalanches: 5m (between: 10m - 2.5m)

Time Step: The time step of the calculation indicates at what intervals the calculations occur. The time step also determines the stability of the calculation . A standard value of 0.005s has been found to be effective. If the topography is simple, the time step can be increased up to 0.02s but this requires increased vigilance for numerical instabilities. In complex topographies it is sometimes necessary to reduce the time step significantly in order to avoid numerical instabilities. This prolongs the simulation time significantly. Opposite slopes in the topography are particularly prone to numerical instabilities. In such cases, the time step may have to be greatly reduced. In the event of a strong numerical instability, the program automatically interrupts the simulation. In the *.dlg-File the comment `Simulation stopped due to NUMERICAL INSTABILITIES !!` appears instead of the results, and a very high maximum flow height is indicated. In such cases it is necessary to attempt to locate the numerical instability. This can be done by observing the maximum velocity in the time steps just before the interruption of the simulation. There is often a strong increase in velocity at the decisive point. If this increase is in the runout area, the „Time Step“ must be reduced (see chapter **??**, p. **??**). If the numerical instabilities still occur with a time step of 0.0002 and at a point of modification of slope angle, the topography should be modified to make the terrain slightly smoother. If the signs of numerical instability are in the avalanche fracture area or in the upper part of the avalanche track and if the velocity at the front of the avalanche is already around 0m/s, the numerical problem is not related to the time step but to the „Max Time“ criterion.

Max Time: This value indicates the latest time at which the calculation is interrupted. The default value is 300s and should not be increased, unless for avalanches with a length of more than 5 km. Generally a simulation comes to an end before reaching this maximum time – i.e. when the amount of snow still moving is smaller than 0.04% of the total amount of snow (`low Mass Flux Condition`) . This additional criterion is necessary because the instability of the calculation increases when the amount of snow is very small (in particular when the terrain alternates between convex and concave sectors). A characteristic sign of this type of instability is a single peak value in the velocity on a slightly flatter part of the upper avalanche track. If such a peak is observed in the Figure and the avalanche has practically come to a standstill in the runout area, the `low Mass Flux Condition` fails. To rectify the error the time limit „Max Time“ can be set to a time between that at which the avalanche front comes to a stillstand and the previous point of interruption. In most cases this solves the numerical instability problem.

4.2 Powder snow avalanches

Element Size: The size of the elements Δx influences the simulations in several manners. The quality of the numerical approximation rises with decreasing element size. A good convergence of the results is obtained with $\Delta x <$ 5–10 m. When the element size is significantly over 10 m, the maximum pressures are up to 50 % too low.

There is an upper limit of 2048 grid points programmed in `SL-1D 0.5.11`. It is therefore recommended to choose $\Delta x > L/1500$, where L is the distance between starting and finishing point on the map.

Maximal Deviation: It is recommended to use values between 5 and 10 m. Smaller values can be used for very smooth topographies and if the avalanche track has abrupt changes of slope and of direction, larger values can improve the stability of the simulation. **Edit** $\rightarrow$ **Calculation Parameters...** $\rightarrow$ **Show Spline** allows to visualise the smoothed avalanche track and any changes of direction in the track (see Figure 44).

Cell Cut-Off: The mass flow is given by $\rho_2 h_2 U_2$ or $\rho_3 h_3 U_3$, the impulse flow by $\rho_2 h_2 U_2^2$ or $\rho_3 h_3 U_3^2$. To simplify things, only one value can be given for all four flows. The default value 10.0 kg m^{-1} s^{-1} or 10.0 kg s^{-2} is adequate for most uses. For very large avalanche or if there are instabilities at the end of the avalanche, higher values up to approximately 30 can be effective. **Beware:** If **Cell Cut-Off** is not reduced for very small avalanches, all flows drop below the limit after the first time step and the whole grid is disabled (appart from the last three cells).

General: Contrary to `FL-1D`, `SL-1D` selects the time step length Δt autonomously for every time step within a predifined range. If Δt drops below 1 ms (in version 0.5.11), this is a sign of numerical instability and the calculation is interrupted.

For topographies with an opposite slope there are often numerical instabilities in `SL-1D 0.5.11` if **Max Time** is too long.

5 Results mode

The results mode can either be directly attained by

- opening a '*.idl' file with **Track** → **Open...** → **Dense Flow Simulation** or
- a '*.idp' file with **Track** → **Open...** → **Powder Snow Simulation**,

or by starting a calculation, when AVAL-1D automatically moves into the results mode. **Run** and various other functions such as **Edit** → **Topography**, **Edit** → **Avalanche Parameters...** and **Edit** → **Calculation Parameters...** as well as **Track** → **Save** and **Track** → **Save as** are no longer active, but the menus **Track Plot** and **Time Plot/Profile Plot** can be selected in the results mode.

From version 1.2 on it is very easy to get information about input and output results by just clicking into the region of interest with your left mouse button. A green point marks the point where you clicked and a information window pops up (**Point Information**), see Figure 46 and 47. This function works for dense flow and powder snow simulations.

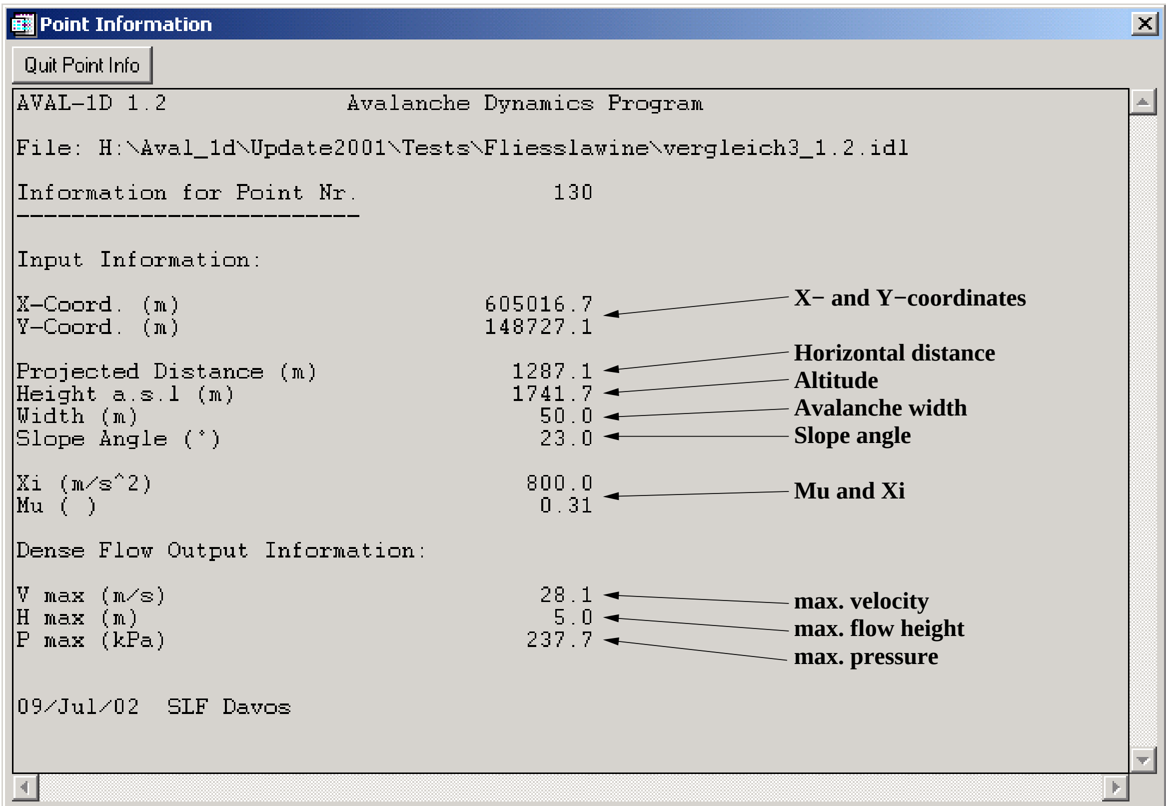


Figure 46: Dense flow information window.

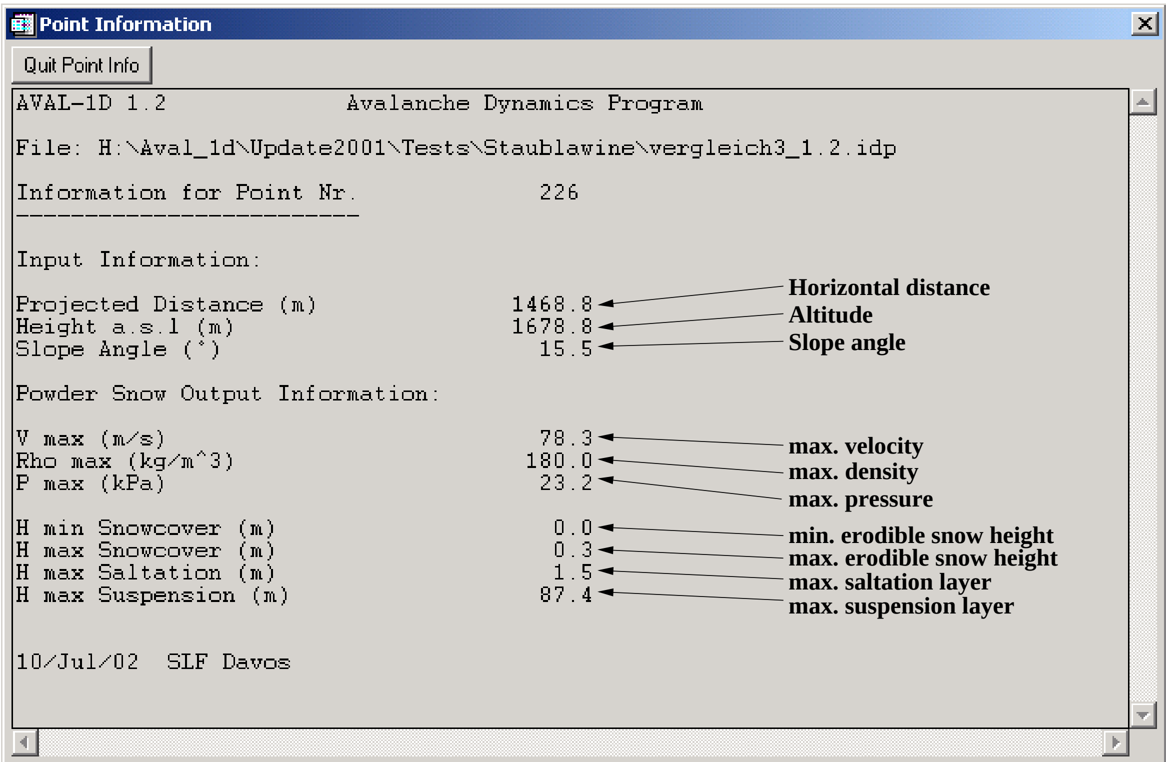


Figure 47: Powder snow information window.

5.1 Dense flow avalanches

The **Track Plot** results of a dense flow calculation can all be visualised in the topography window and the **Time Plot** results can be seen in the time plot window. No results are shown in the parameter window (see Figure 1, p. 2).

5.1.1 Track Plot

Chapter 2.5, p. 20 shows which results can be shown in the `DENSE FLOW` mode:

Dense Flow

Track Plot
- Snow Height
- Velocity
- Pressure
- Max Snowheight
- Max Velocity
- Max Pressure
- Show Logfile
- Print Logfile
- Pressure Zones >
- Endmark On/Off
- Show Xi (Input Parameter)
- Show Mu (Input Parameter)
- Show Width

Powder Snow

Track Plot
- Snow Height
- Velocity
- Pressure
- Density
- Track Width − Bottom
- Track Width − On/Off
- Topography On/Off
- Print Logfile
- Max Values / Time Step Values

Snow Height, Velocity & Pressure: Snow height, velocity and pressure can be animated. To do this, push the menu button **Animation**. In the lower left hand corner of the topography window a scale appears corresponding either to a snow height of 2 m, a velocity of 20 m/s or a pressure of 30 kPa. This scale can be switched off in the properties menu (**Track** → **Properties**) by deactivating the check box **Show legend** . In the menu **Edit** → **Scaling...** these three functions can be scaled with **Edit** → **Scaling...** → **Change Scaling**.

Max Snowheight, Max Velocity & Max Pressure: These functions can not be animated. The maximum values of snow height, velocity and pressure are shown for every point in the topography. Figure 48 shows the maximum velocity of a dense flow avalanche calculation in Samedan.

Edit → **Scaling...** → **Change Scaling** allows to change the difference between the maximum on the velocity axis (y-axis on the right hand side of the window) and the maxima of the velocity curve (**Vmax-Offset**) . This can also be done with **Hmax-Offset** (snow height) and **Pmax-Offset** (pressure).

Show & Print Log file: During a dense flow avalanche calculation, a log file (`*.dlg`) is written, see chapter 6.3, p. 79 for details.

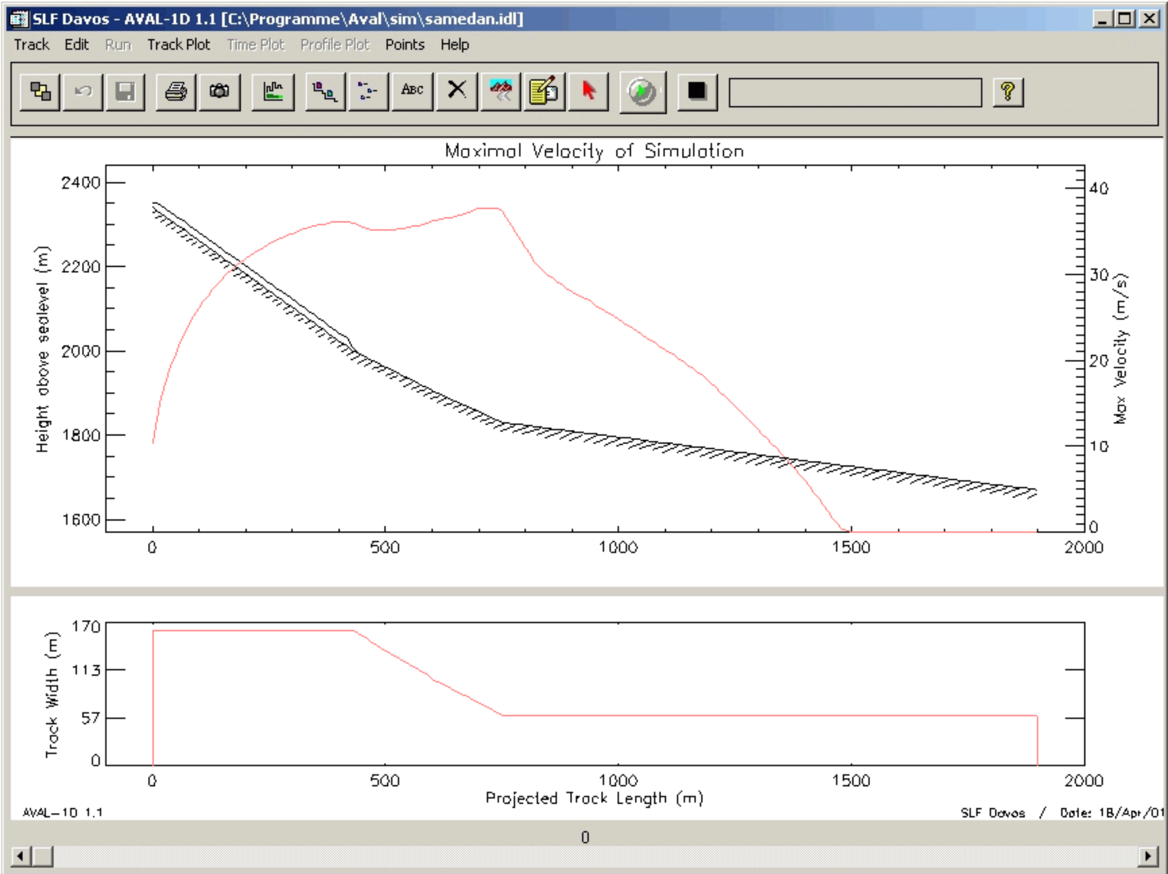


Figure 48: Display of the maximum velocity in a dense flow avalanche calculation (Samedan).

Track Plot → **Print Logfile** allows to print the log file directly from `AVAL-1D` on the printer. If you have problems to print the log file, check the settings of the printer port in **Track** → **Properties** (see chapter 6.2, p. 75).

Pressure Zones and Endmark On/Off: With **Track Plot** → **Pressure Zones** → **On/Off** it is possible to display danger zones in colour. In Switzerland, 30 kPa (red / blue) and 3 kPa (blue / white) are used for these pressure limits. In other countries, these values differ. With **Track** → **Properties** → **Dense Flow Pressure Limits** or **Track Plot** → **Pressure Zones** → **Edit Value** these values can be changed and saved.

With **Endmark On/Off** it is possible to mark the end of the observed avalanche in order to be able to compare it with the calculated runout area (see appendix A.2, p. 94). The Endmark function is only possible, if the mark has been set in the input-file. Both functions are shown in Figure 87, p. 109.

5.1.2 Time Plot

In order to be able to follow the evolution of the velocity at several points, it is necessary to have marked points along the topography (see chapter 2.8, p. 27).

Dense Flow	**Powder Snow**
Time Plot	**Time Plot**
- Snow Height	- Snow Height
- Velocity	- Velocity
- Pressure	- Pressure
- Combination	- Density

The **Time Plots** can be scaled (**Change Scaling**), printed (**Print**) and comments can be added (**Annotate** – see Figure 49).

Figure 49: Menu of timeplot window.

The following results can be shown:

Snow Height, Velocity & Pressure: Evolution of the snow height, velocity and pressure – see Figure 50.

Combination: Snow height, velocity and pressure are shown on one page.

5.1.3 Overlaying dense flow avalanche simulations

Using **Track** → **Overlay...** → **Add New File** it is possible to overlay several simulation results (i.e. to open several `'*.idl'` files simultaneously). The following points must however be respected:

- The topography must not be changed.
- In the **Dense Flow Global Parameters** (see Figure 43, p. 50), the **Physical Parameters** can be modified. In the **Simulation Specific Parameters** only **Max Time (s):** may be modified. The remaining parameters must be identical in all files which are to be overlaid.

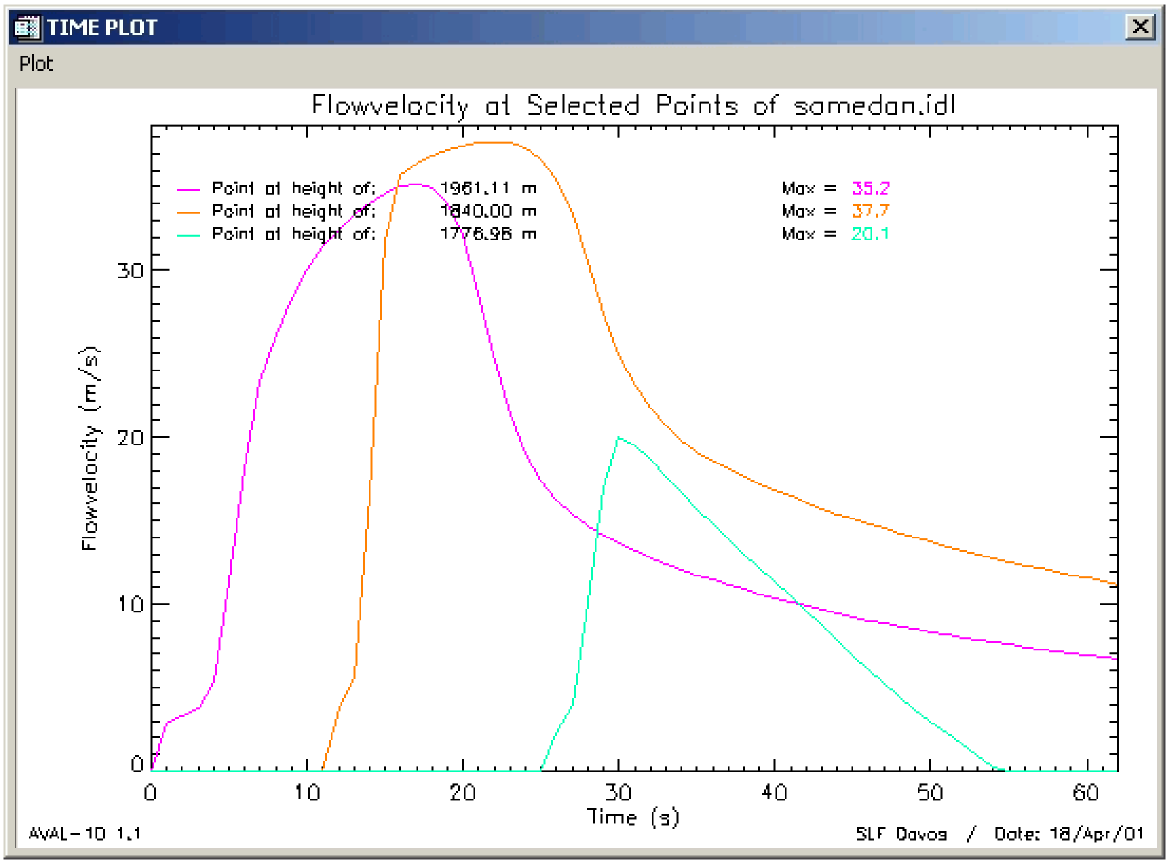


Figure 50: **Time Plot** window in the DENSE FLOW mode. The velocity at three points during a simulation is shown.

The added files can be removed separately with **Track** → **Overlay...** → **Remove Last File**. If the above mentionned points have not been respected, AVAL-1D informs, that it is not possible to overlay the selected files.

5.2 Powder snow avalanches

Contrary to dense flow avalanches, the results available in **Track Plot** results are shown in the parameter window for powder snow avalanche calculations, and the **Time Plot/Profile Plot** (temporal evolution and vertical profiles of the maximum values) are shown in separate windows (**Timeplots**- and **Profiles** windows).

5.2.1 Track Plot

As already mentionned in chapter 2.5, p. 20 , the following `POWDER SNOW` results can be shown:

Dense Flow

Track Plot

- Snow Height
- Velocity
- Pressure
- Max Snowheight
- Max Velocity
- Max Pressure
- Show Logfile
- Print Logfile
- Pressure Zones >
- Endmark On/Off
- Show Xi (Input Parameter)
- Show Mu (Input Parameter)
- Show Width

Powder Snow

Track Plot

- Snow Height
- Velocity
- Pressure
- Density
- Track Width − Bottom
- Track Width − On/Off
- Topography On/Off
- Print Logfile
- Max Values / Time Step Values

Snow Height: The powder snow avalanche layers (erodible snow layer, saltation and suspension layer) can be shown in both windows (**Track Plot** → **Snow Height**), animated (**Animation-Button**) and scaled (**Edit** → **Scaling...** → **Avalanche Layers (Top Display)** or **Edit** → **Scaling...** → **Scaled Layers (Bottom Display)**) . If more exact details about the layer sizes at selected points in the topography are wanted, the points can be selected with **Points** → **Select with Cursor** and the results shown with **Time Plot** → **Snow Height**.

Pressure, Velocity und Density: The results of the powder snow avalanche simulation are shown in the parameter window. These are pressure, velocity and density. Figure 51 schematically shows the constituents of a powder snow avalanche.

This figure clearly shows that the three layers do not have the same velocity, pressure or density. It is therefore necessary to specify at which heights (vertically above the ground) the results are of interest. This can be done with the dialogue window **Selection of Height Above Ground**, see Figure 52. Figure 54 illustrates this type of representation, with three heights of observation.

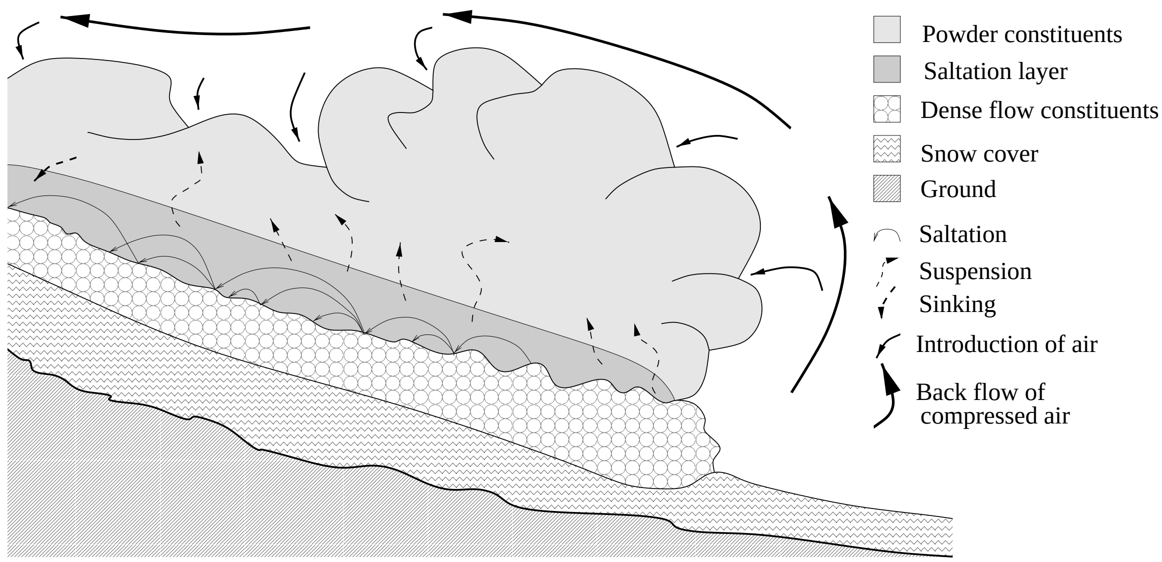


Figure 51: Schematic representation of the constituents of a powder snow avalanche.

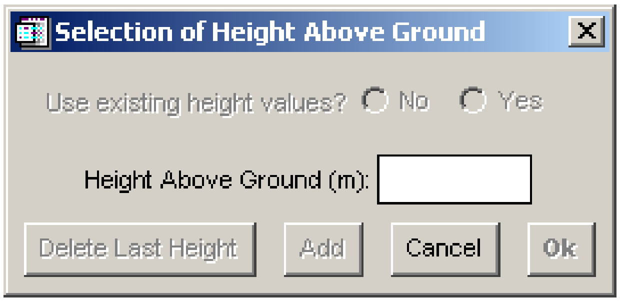


Figure 52: Entering the heights above the ground in the menu points **Track Plot** → **Pressure**, → **Velocity** or → **Density**.

After entering a height, press **Add**, after which an additional height can be entered or the process stopped with **Ok**. Usually one wants to see the velocity, pressure, and density at the same heights. When these heights have been entered once, they can be adopted with the option **Use existing height values** by simply selecting **Yes** and then **Ok**.

The results can then be animated by pressing the **Animation-Button** or by having the maximum values of a simulation shown. In order to do this, press the right mouse button in the lower window and choose **Max Values**. If only the parameter window is desired, it can be selected with **Track Plot** → **Topography On/Off** (see p. 66).

Track Width-Bottom & Track Width On/Off: This functions allow to visualise the width of the avalanche track in the topography window (**Track Width On/Off**) and in the parameter window (**Track Width-Bottom**) - (see Figure 53).

Topography On/Off: As almost all results are shown in the parameter window (i.e. in the smaller window), it is possible to enlarge it to full size using **Topography On/Off**. To return to the previous state, press on the same function again.

Maximum Values and Time Step Values: These functions can only be used in the `POWDER`

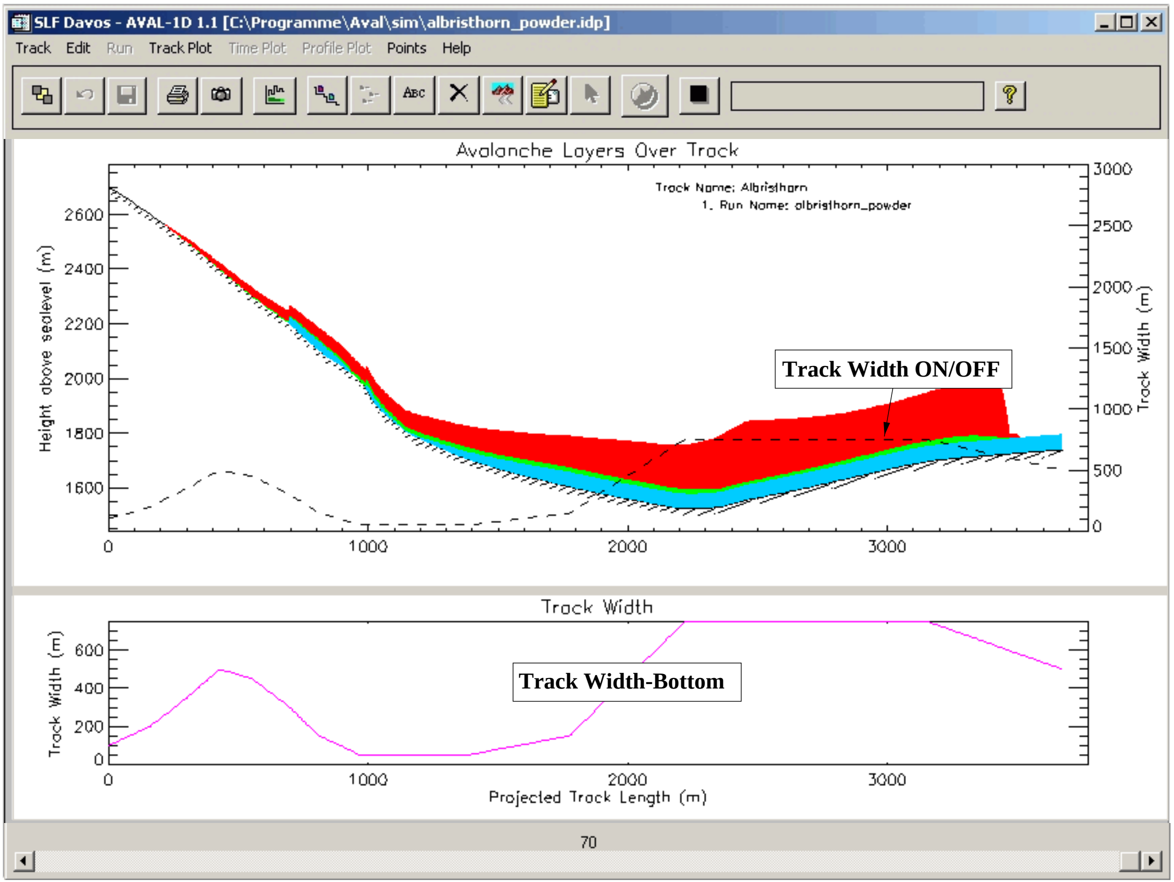


Figure 53: If the width of the avalanche track is shown in the parameter window, the time step bar is disabled.

SNOW mode. **Time Step Values** is always active, i.e. the results of a certain time step are shown. If the maximum values need to be seen for each point in the topography, press the right mouse button and choose **Max Values** or use **Track Plot** → **Max Values / Time Step Values**. This function is used very frequently as it is equivalent to a summary of the simulation.

5.2.2 Time Plot

In order to be able to use this function, points must also be selected along the topography.

Snow Height: The development of the heights of the three layers (erodible layer, saltation- and suspension layers) are given for every point during the simulation.

Velocity, Density & Pressure: The evolution of velocity, density and pressure is shown for selected points during a simulation. The heights of interest must also be entered here (see Figure 52).

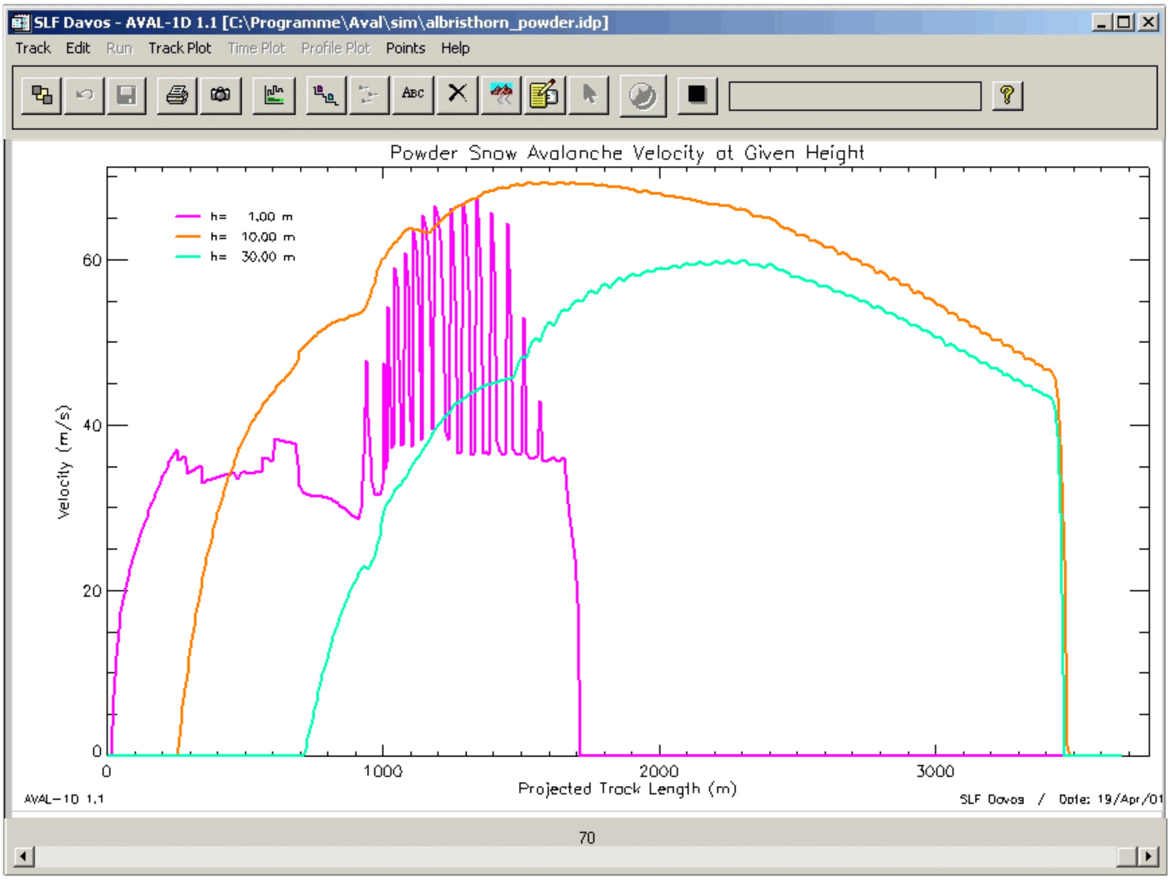


Figure 54: Display of the velocities of a powder snow avalanche at a fixed point in time (50th time step) at three different heights above the ground (1, 10 and 30m). After 700m the height of the powder snow avalanche is greater than 30 m. After 250m the upper boundary of the saltation layer is more than 1 m above the ground and the (significantly lower) velocity of the saltation layer is shown.

5.2.3 Profile Plot

The vertical profiles of the maximum values (of velocity, pressure and density) which were attained during the simulation can be shown here. Figure 55 shows the velocity profile at three points.

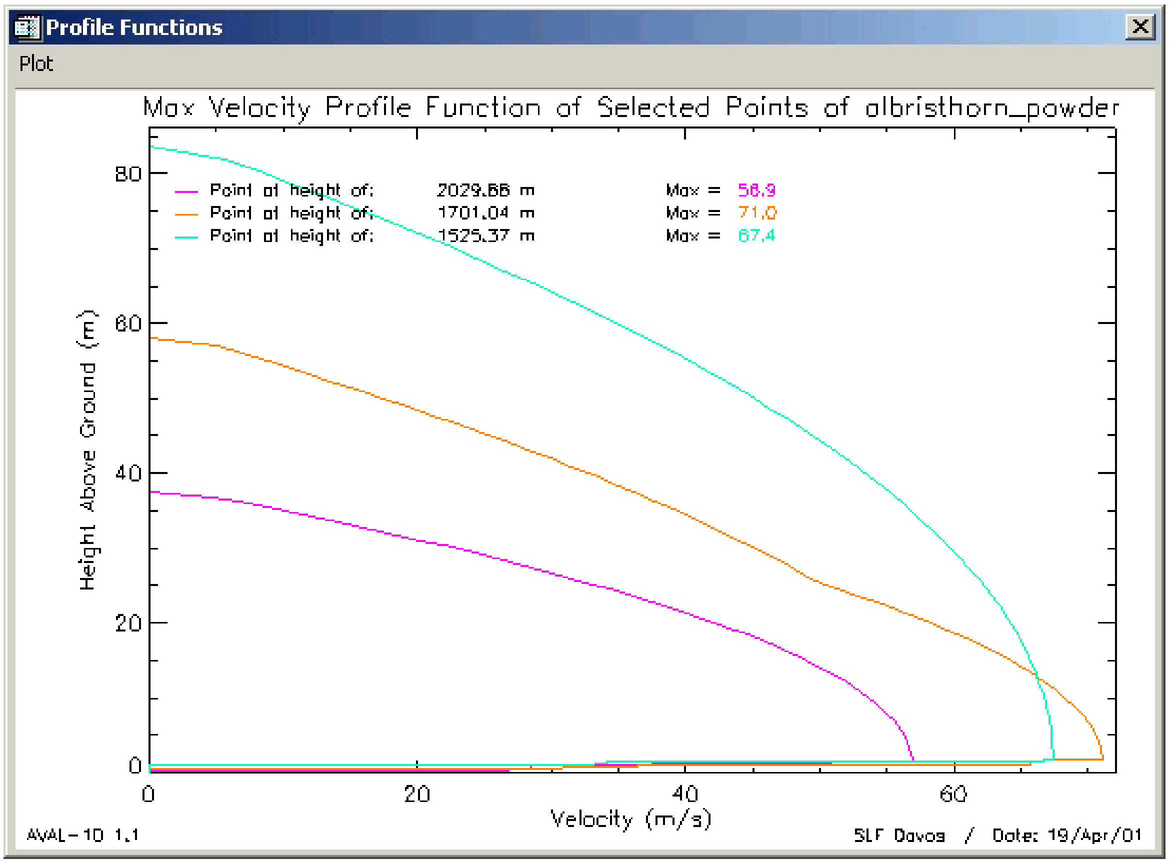


Figure 55: Maximum vertical velocity profiles at three selected points in a separate window.

5.2.4 Overlaying powder snow avalanche simulations

Track → **Overlay...** → **Add New File** allows to overlay several simulation results (i.e. to open several `'*.idp'` files simultaneously). The following points must be respected:

- The topography must not be modified.
- In the **Powder Snow Global Parameters** (see Figure 43, p. 50) only **Maximal Deviation (m):** and **Cell Cut-Off:** can be changed. The remaining parameters must be identical in all files to be overlaid.

The added files can be removed with **Track** → **Overlay...** → **Remove Last File**. If the above mentionned points have not been respected, `AVAL-1D` informs, that it is not possible to overlay the selected files.

6 Miscellaneous

6.1 Printing and data export

- **Track** → **Print Setup**

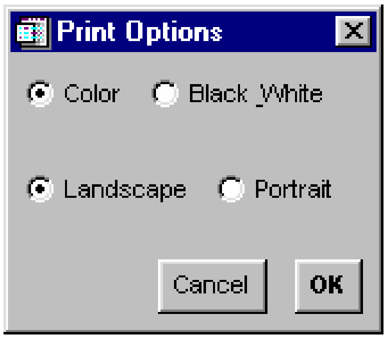


Figure 56: **Print Options** dialogue window.

In general, plots are printed or exported in colour. If you want to print on a black-and-white printer, choose **Black-White** in **Track** → **Print Setup**.After that, the plots will not be in colour any more, but dotted and dashed. It's also possible to export black-and-white EPS-files, whereas GIF-, TIFF- and BMP-files are not exportable in black-and-white.

Topography-plots are printed and exported in landscape-mode (cross-format). You can change that by clicking the second position on **Portrait**. Time plots and Profile plots are always printed in portrait mode.

- **Track** → **Print**

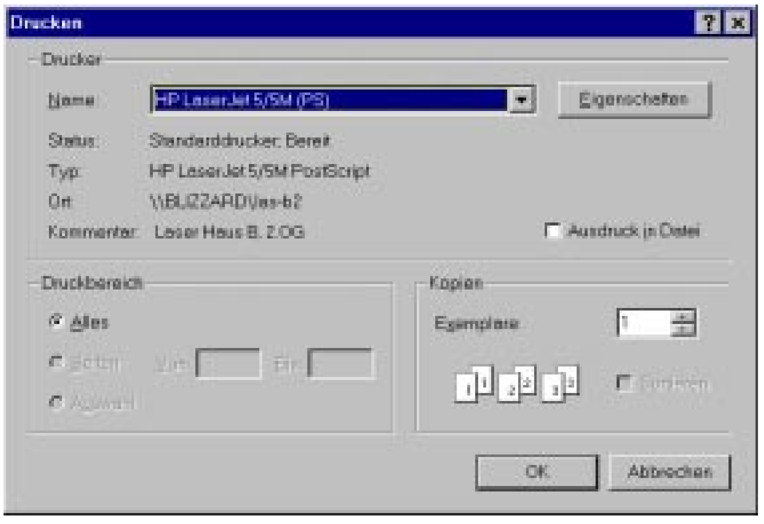
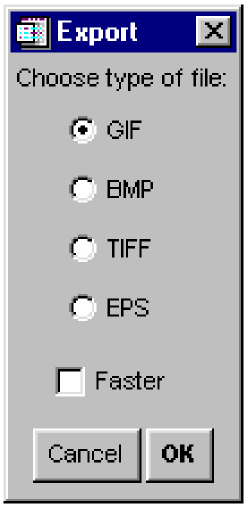


Figure 57: Windows print dialogue window.

The Windows printer can be selected here. If a black-and-white printer is selected, it is important to check that the button **Black & White** is active in **Track** → **Print Setup**. It should be noted that when **OK** is pushed, the job is sent to the printer. Any **Black & White** settings must be activated before **Track** → **Print**.

- **Track** → **Export...** → **Display**



There is currently a choice of four different graphics formats: `GIF`, `TIFF`, `EPS` and `BMP`. These files can then be imported into Word e.g.

- **Track** → **Export...** → **Data**

The most important results can be exported as `ASCII` files:

  - `DENSE FLOW:` → Max Snowheight, Max Velocity and Max Pressure
  - `POWDER SNOW:` → Velocity, Pressure and Density, for every time step and when **Maximum Values** is activated.

A name is suggested in a dialogue window (e.g. `test_maxsnow.txt`, see Figure 58), which is however not obligatory and which can be modified. This `ASCII`-file can then be read into Excel for example and processed there. The file header contains information about the data, such as date, parameters, column headings, see Figure 59.

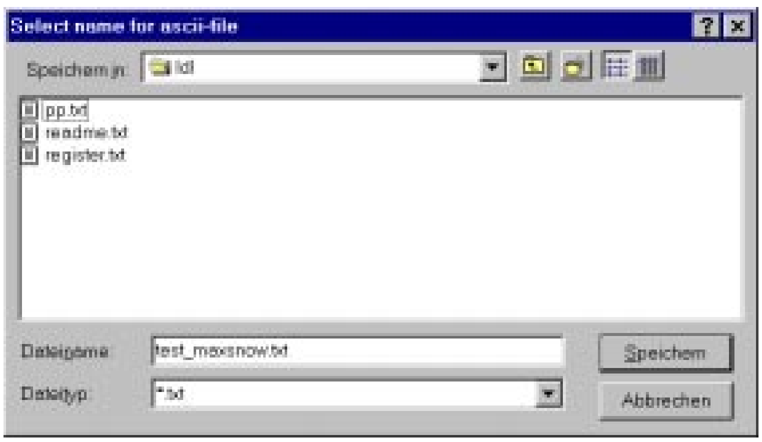


Figure 58: This dialogue window appears if one wants to export `ASCII`-files.

```
      Printing date           : 24/Apr/01
      Parameter               : max_snowheight (m)
      1. column               : topo_data (m)
      2. column - Filename    : test.idl
---------------------------------------------------------------
      0.00000      0.00000
      10.0000      0.00000
      20.0000      1.33000
      30.0000      1.30000
      40.0000      1.28000
      50.0000      1.25000
```

Figure 59: Kopf einer ASCII-Datei

- **Time Plot- and Profile Plot-window → Print**

  These functions work exactly like **Track → Print**. It is however not yet possible to export ASCII files.

6.2 Properties - the file *properties.dat*

General settings (line thickness, title and legend font size, printer port, working directory etc.) can be changed and saved within the file *properties.dat*. *properties.dat* is an ASCII file and is located in the ∼ *Rsi**Idl52**lib**hook* directory. Most settings can be changed directly within the **Track → Properties** dialogue window. Figure 60 shows *properties.dat* with short explanations on the right side. The following section will give more details about all the settings.

- **Plot scaling**

  All the snowheights (in dense flow and powder snow mode) as well as dense flow velocity and pressure can be scaled. Command for scaling: **Edit Scaling → Scaling...**

- **Offset**

  Study Figure 61 below to understand how the 'Offset' works. In dense flow simulations offsets are used to change the scale of maximum snowheight, velocity and presssure plots. Command: **Edit Scaling → Scaling... → Change Scaling**.

  Explanation: 'Offset' is the difference between the maximum value of the plot and the maximum value of the y-axis. With a maximum snowheight of 3.1 m and an 'Offset' of 0.5 m the maximum of the y-axis is 3.6 m (see Figure 61 above).

- **Font sizes**

  Font sizes of titles, annotations and legends can be changed and saved in **Track → Properties**.

- **Line Thickness**

  The thickness of lines can be changed and saved in **Track → Properties**. One differentiate between lines on the screen and when printing.

- **Show Legend:** The snowheight legend can be switched on and off.

Scaling Factors:	Scaling Factors:
---------------	---------------
50.0000	Scale of erodible snowheight (SL)
30.0000	Scale of saltation layer (SL)
2.00000	Scale of suspension layer (SL)
16.0000	Scale of snowheight (FL)
3.00000	Scale of velocity (FL)
0.500000	Scale of pressure (FL)
0.500000	Offset of maximum snowheight (FL)
5.00000	Offset of maximum velocity (FL)
50.0000	Offset of maximum pressure (FL)
General Properties:	General Properties:
------------------	------------------
1.00000	Title font size
0.800000	Font size of legend and annotations
1.00000	Line thickness screen
2.50000	Line thickness printing/EPS-files
0.000000	Legend On/Off
0.000000	Additionnal PS-Parameters On/Off
1274.00	Width of main window in pixel
578.667	Height of upper main window in pixel
1274.00	Width of main window in pixel
289.333	Height of lower main window in pixel
30.0000	Pressure limit between red and blue pressure zone
14.0000	Font size dialogue windows
1.00000	Pressure limit On/Off
lpt1	Printer port
C:\Programme\aval\ava\	Working directory
C:\Programme\Netscape\netscape.exe	Exe-file of internet browser
1.00000	Input point marks On/Off
1.00000	Vertical grid lines On/Off
1.00000	Horizontal grid lines On/Off
3.00000	Pressure limit between blue and white pressure zone
0.00000	0: german help, 1: english help
0.00000*	Option 'release volumen' On/Off

Figure 60: All settings within *properties.dat*.

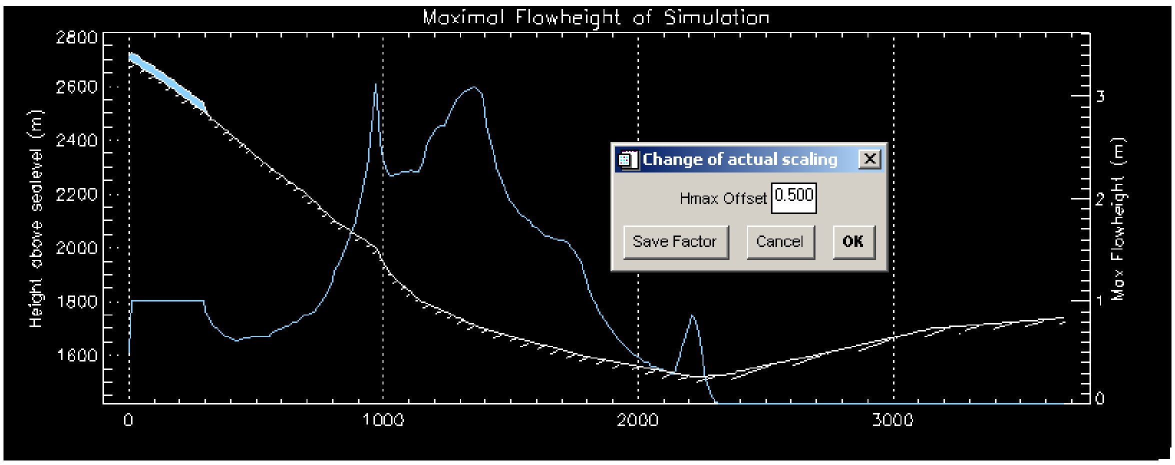


Figure 61: Offset - explanations.

- **Show All Powder Snow Parameters:**

  The powder snow parameter dialogue window is reduced and the suspension layer parameters have been removed. If you nevertheless want all parameters, activate this button.

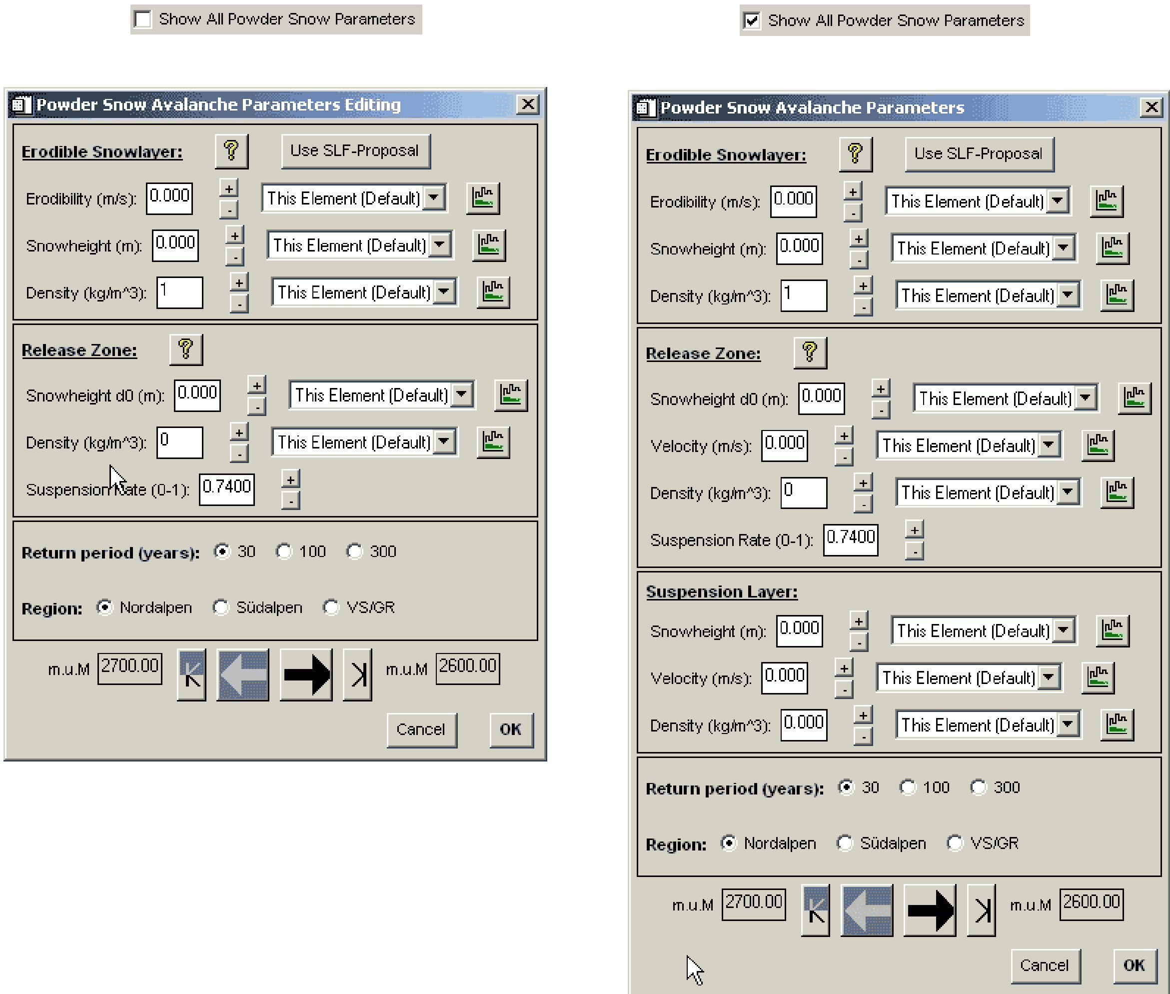


Figure 62: Default setting on the left side and all parameters on the right side.

- **Pixel-dimensionens of user interface**

  Height and width of the user interface are defined here. If you change the size of the user interface, these values are updated automatically in *properties.dat*.

- **Pressure limit red / blue and blue / white**

  In Switzerland, 30 kPa (red / blue) and 3 kPa (blue / white) are used for these pressure limits. In other countries, these values differ. With **Track** → **Properties** → **Dense Flow Pressure Limits** or **Track Plot** → **Pressure Zones** → **Edit Value** these values can be changed and saved.

- **Show Zone Limit (Red Line):**

  This function was introduced especially for countries, which don't have pressure zone limits (red-blue at 30 KPa in Switzerland). Deactivating this button causes the red line to vanish.

- **Printer Port**

Normally, printers are connected over a parallel port (called LPT-port) to the computer. Within AVAL-1D the default setting is LPT-port 2 (LPT2). If you connected your printer over LPT1 or if you print over a network, then it is possible, that you cannot print the log file and the info file.

Instructions to change the printer port: If you do not know how your printer is connected to your computer, please do the following (otherwise enter your printer port into the field Printer Port):

Windows 9x

Open **Start** → **Settings** → **Printer**, mark your printer and choose **File** → **Properties**. Click on the register *Details* and copy the field *'Connection for print output:'* into the field *Printer Port* in the dialog window *Properties* (see marked field in Figure 63 below).

Windows 2000/XP

Open **Start** → **Settings** → **Printer**, mark your printer and choose **File** → **Properties**. Click on the register *Ports* and remember the field *'Port'*, see Figure 63 below. There will be written something like: *server:printername*. Then copy the following into the field *Printer Port*: *server**druckername*

- **Working Directory:**

  Choose your personnel working directory here. Press **Browse** to choose a new directory. Each time you start `AVAL-1D`, the default directory will be always your working directory.

- **Internet-Browser - exe-file**

  Choose your internet browser's exe-file. Press **Browse** to choose a new file, e.g. *C:* \ *Programme* \ *Internet Explorer* \ *iexplore.exe*. You need the internet browser to visualise the help menu.

- **Input point marks**

  By enabling and disabling the appropriate checkbox within **Track** → **Properties** the input point marks can be activated or not.

- **Horizontal / vertical grid lines:**

  By enabling or disabling the appropriate checkbox horizontal or vertical gridlines can be activated or not.

- **Option 'Release Volume'** This parameter can be changed only by opening *properties.dat* in a text editor (e.g. Word or Wordpad).

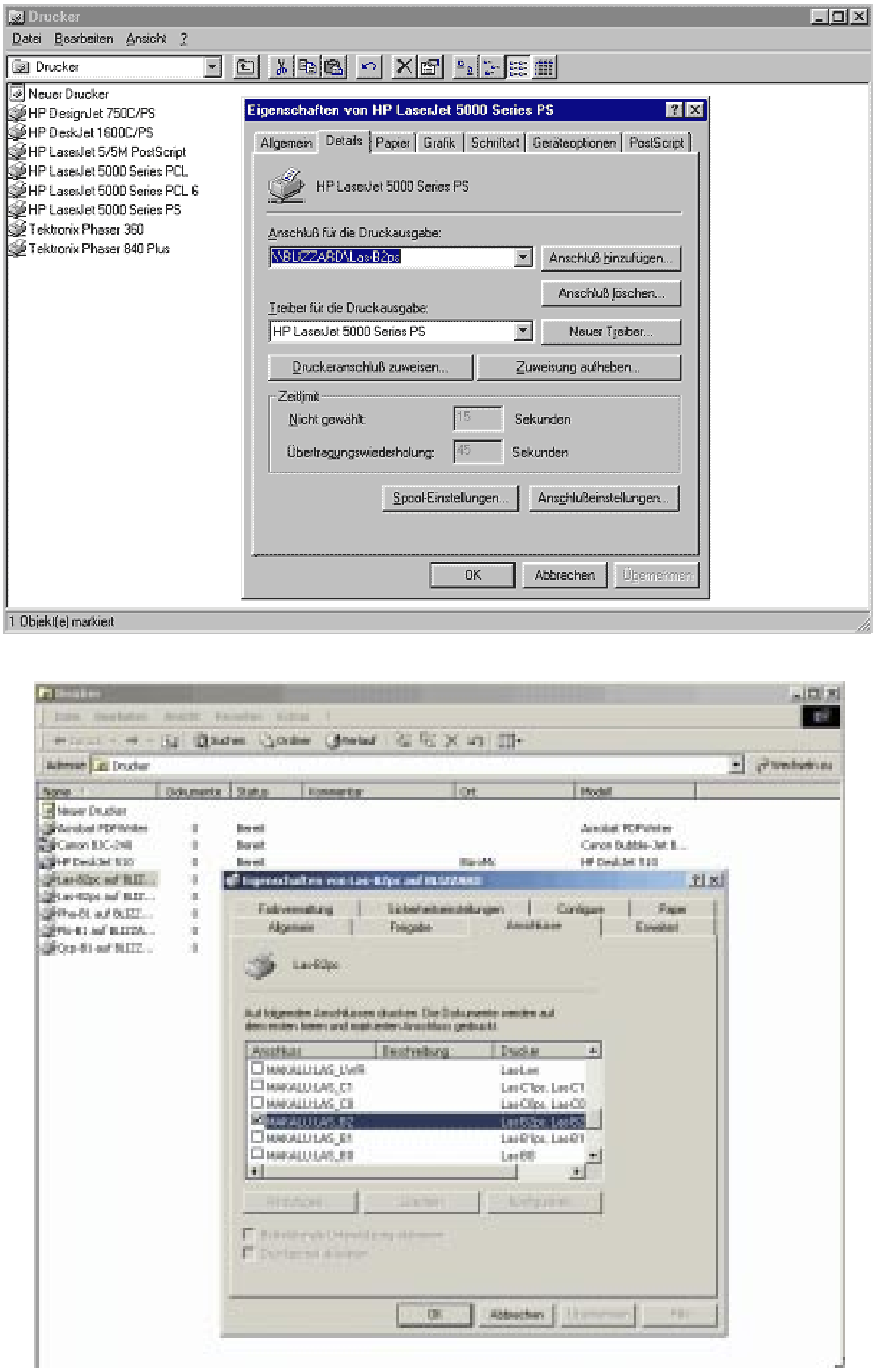


Figure 63: Up: Printer port Windows 9x; down: printer port Windows 2000 / XP

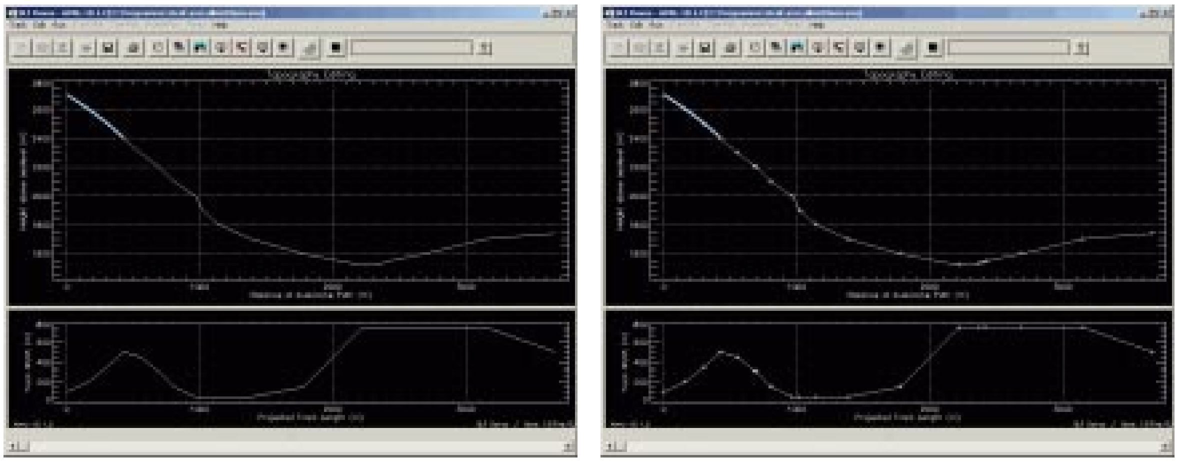


Figure 64: Left: without input point marks; right: with marks

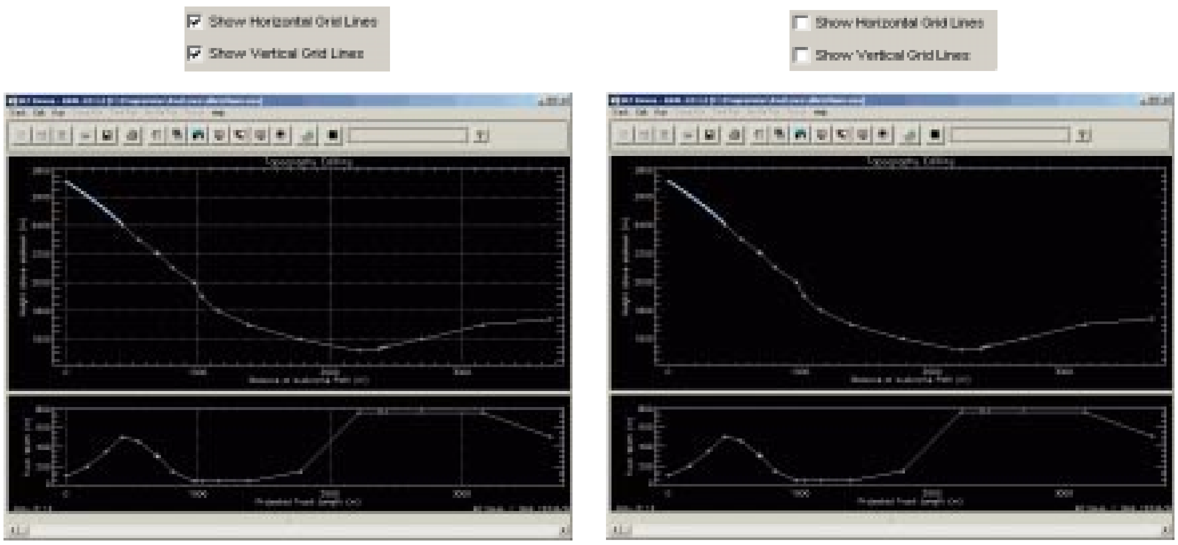


Figure 65: Left: without grid lines; right: with grid lines

0.0 in properties.dat

1.0 in properties.dat

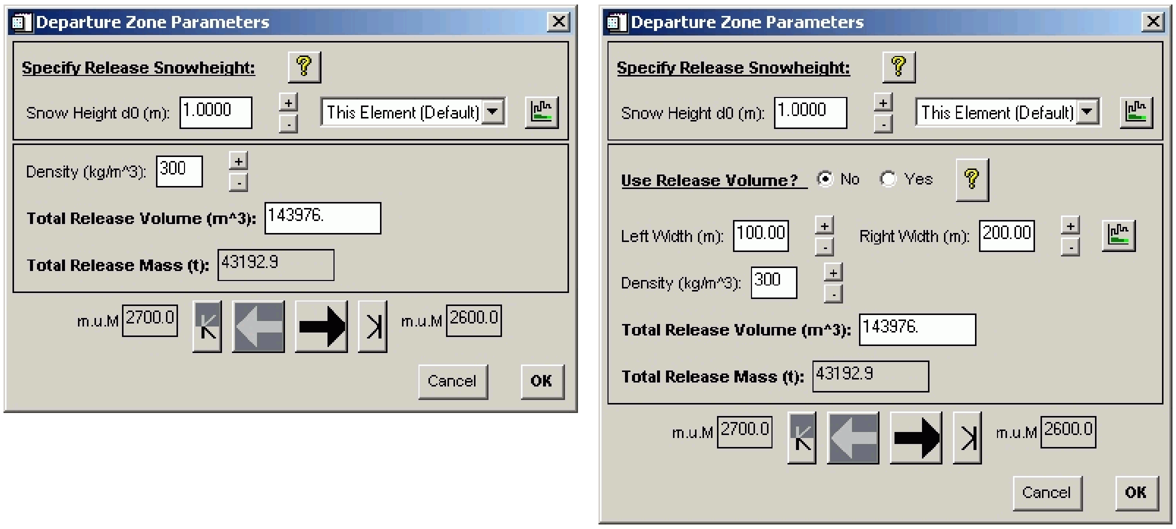


Figure 66: Left: default setting; right: with release volume

6.3 Log file

During both dense flow and powder snow avalanche calculations, a log file is written. Dense flow log files have the ending `*.dlg`, powder snow log files `*.plg`.

6.3.1 Dense flow avalanche

- Date of simulation (**Date of Calculation**).
- The corresponding Output-file (`*.idl`, **Name of the corresponding output file**).
- The `SIMULATION RESULTS` are in the next session. Explanations:
  Reason for the End of the Simulation
  General Simulation Parameters
  Parametric Description of the Runout Zone
  Monitoring Points
  Projected distances and Heights in the Avalanche Track
  Summary of the comparison to the Control Values).
- The last part contains the input data (`INPUT DATA`):
  Global Parameters
  Monitoring Points (if defined)
  Coordinates
  Local Parameters.

```
*********************************
A V A L - 1 D --- L O G F I L E
*********************************

Date of Calculation: Mon Jul 22 14:48:57 2002

Name of the corresponding output file:
C:\Programme\Aval\ava\samedan.idl

************************************
S I M U L A T I O N   R E S U L T S
************************************

Reason for the End of the Simulation
------------------------------------

+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Simulation stopped at TimeT =  62.00 s due to the low Mass Flux
Condition (Total Mass/2500/s) of     42 m3/s
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++


General Simulation Parameters
-----------------------------

Calculated Return Period:          300 years
Overall Max Velocity:        37.84 m/s
Overall Max Height:         5.56 m
Total Volume in System:       105012 m3
Minimal Mass Flux Condition:           42 m3/s
Total Mass in System:        31504 t
Mass Error in System: -2.481140e-009 Percent


Parametric Description of the Runout Zone
-----------------------------------------

Maximal Depth at the last simulation step:         4.44 m
Position of Maximal Depth:
 a) projected avalanche length:      1270.00  m
 b) altitude above sealevel:      1757.44  m
Mean Mass Position (half of the mass above/below this position) :
 a) projected avalanche length:      1160.00  m
 b) altidude above sea level:      1772.79  m
Projected Length considered for Mean Deposition Depth Calculation
(+/- one standard deviation from Mean Mass Position)
 from       980.00  m to       1340.00 m
Mean Deposition Depth :         3.11 m


Monitoring Points
-----------------
                             Anriss:
- Max Velocity        10.39 m/s
- Max Height         0.60 m
                          Sturzbahn:
- Max Velocity        36.01 m/s
- Max Height         1.25 m
                             Huette:
- Max Velocity        37.56 m/s
- Max Height         3.70 m
                               Baum:
- Max Velocity         0.01 m/s
- Max Height         0.00 m


Projected Distances and Heights in the Avalanche Track
------------------------------------------------------
Limit between High and Low pressure Zone:         30.0 kPa
Limit defining end of Low Pressure Zone:          3.0 kPa

Distance Begin of Starting Zone - End of High Pressure Zone:         1340 m
Distance Begin of Starting Zone - End of Low Pressure Zone:         1450 m
Distance End of High Pressure Zone - End of Low Pressure Zone:          110 m
Height above sealevel of End of High Pressure Zone:      1747.67 m
Height above sealevel of End of Low Pressure Zone:      1732.33 m
---> Control Value of Length of the Avalanche:         1610 m

Distance                              Anriss - End of High Pressure Zone:         1340 m
Distance                              Anriss - End of Low Pressure Zone:         1450 m
Distance                           Sturzbahn - End of High Pressure Zone:          910 m
Distance                           Sturzbahn - End of Low Pressure Zone:         1020 m
Distance                              Huette - End of High Pressure Zone:          590 m
Distance                              Huette - End of Low Pressure Zone:          700 m
Distance                                Baum - End of High Pressure Zone:         -270 m
```

```
Distance                        Baum - End of Low Pressure Zone:        -160 m


Summary of the comparison to the Control Values
-----------------------------------------------

Subject Sim. Val. Ctrl. Val. Percentage
--------------------------------------------------------
Avalanche Length [m]:     1450     1610      -10
Flow Velocity Points:
                             Anriss [m/s]:    10.39    15.00   -44.33
                          Sturzbahn [m/s]:    36.01    21.00    41.69
                             Huette [m/s]:    37.56    25.00    33.45
                               Baum [m/s]:     0.01    19.00 -276963.83
Flow Height Points:
                             Anriss [m]:     0.60     1.30  -115.73
                          Sturzbahn [m]:     1.25     1.30    -4.25
                             Huette [m]:     3.70     2.50    32.43
                               Baum [m]:     0.00     3.50 -9999.00

***************************
E N D   O F   R E S U L T S
***************************


********************
I N P U T   D A T A
********************

(Copy of the '*.ava' - Input File)
----------------------------------
# AVAL-1D INPUT FILE
# SLF-PROGRAM FOR ONE-DIMENSIONAL AVALANCHE SIMULATIONS
# VERSION 1.2, November 2001
# ====================================================
#
| NAME AND INFORMATION
#
Track_Name Vereinfachtes Profil Samedan
Run_Name
#
INFO----------------------------------------
Vereinfachtes, den Richtlinien
nachgebautes Profil Samedan.
----------------------------------------INFO
#
| DENSE FLOW GLOBAL PARAMETERS
#
Elem_Size              10.0
Dump_Interval           1.0
Max_Time                300
Return_Period           300
Red_Blue_Limit         30.0
Blue_White_Limit        3.0
Rho                     300
Lambda                  2.5
Time_Step            0.0050
Endmark x               0.0
Endmark y            1610.0
#
| POWDER SNOW GLOBAL PARAMETERS
#
Elem_Size            10.0
Dump_Interval         1.0
Max_Time              200
Region          Nordalpen
Return_Period          30
Max_Dev              10.0
Susp_Rate            1.00
Cell_Cut            10.00
#
Air_Density 1.0
Particle_Density 917.0
Gravity 9.81
Fluid_Viscosity 1.7e-05
Settling_Velo 1.0
#
C_mu 0.09
C1_eps 1.44
C2_eps 1.92
C3_eps 0.8
Sigma_c 1.0
Sigma_k 1.0
Sigma_eps 1.3
#
```

```
Velo_Prof_Coeff_0 1.4
Velo_Prof_Coeff_1 0.0
Velo_Prof_Coeff_2 -1.4
#
Conc_Prof_Coeff_0 1.3333
Conc_Prof_Coeff_1 -0.66667
Conc_Prof_Coeff_2 0.0
#
Turb_Prof_Coeff_0 1.0
Turb_Prof_Coeff_1 0.0
Turb_Prof_Coeff_2 0.0
#
Diss_Prof_Coeff_0 1.0
Diss_Prof_Coeff_1 0.0
Diss_Prof_Coeff_2 0.0
#
Threshold_Factor 10.0
Alpha 0.02
Beta_0 0.02
Beta_1 0.5
Beta_2 1.0
Beta_3 1.2
Beta_4 1.0
# Gamma_1 = PROF_VEL_0
# Gamma_2 = PROF_CONC_0
Gamma_3 2.0
Gamma_4 3.0
#
Max_Time_Step 0.2
Min_Salt_Height 0.1
Min_Salt_Velo 0.1
Max_Salt_Density 100.0
Min_Susp_Height 0.1
Min_Susp_Velo 0.1
Min_Susp_Turb 1.0e-06
Min_Susp_Dissip 1.0e-04
Courant_Nr 0.85
Relaxation_Factor 0.7
#
Min_Salt_Mass_Flux          10.0
Min_Salt_Mom_Flux           10.0
Min_Susp_Mass_Flux          10.0
Min_Susp_Mom_Flux           10.0
#
| COORDINATES
#
Number_of_Points         8
#
# No       X            Y          Z          W
   0         0.000         0.000  2340.000   160.000
   1         0.000       417.000  2010.000   160.000
   2         0.000       430.000  2000.000   160.000
   3         0.000       610.000  1900.000   100.000
   4         0.000       750.000  1830.000    60.000
   5         0.000      1610.000  1710.000    60.000
   6         0.000      1750.000  1690.000    60.000
   7         0.000      1900.000  1670.000    60.000
#
#
| MONITORING POINTS
#
Monitoring Points           4
# Node Nr.               Name            Obs V  Obs H
   0                         Anriss  15.0   1.3
   2                      Sturzbahn  21.0   1.3
   4                         Huette  25.0   2.5
   5                           Baum  19.0   3.5
#
| DENSE FLOW LOCAL PARAMETERS
#
# No    Mu    Xi      h    Rel  Canal Slope    Dist   Vel
   0  0.160  2500  1.2000   1     0   38.4     531.8  0.00
   1  0.160  2500  1.2000   1     0   37.6      16.4  0.00
   2  0.160  2500  0.0000   0     0   29.1     205.9  0.00
   3  0.160  2500  0.0000   0     0   26.6     156.5  0.00
   4  0.200  1750  0.0000   0     1    7.9     868.3  0.00
   5  0.200  1750  0.0000   0     1    8.1     141.4  0.00
   6  0.200  1750  0.0000   0     1    7.6     151.3  0.00
#
| POWDER SNOW LOCAL PARAMETERS
#
# No Rough Erodi EroH EroRho SaltH  SaltV SaltD SuspH  SuspV  SuspD Turbulent  Dissipat
   0  0.10  0.20  0.00 150.00  1.50  0.00  30.00  0.00  0.00  0.00 0.00e+000 0.00e+000
   1  0.10  0.20  1.00 150.00  1.50  0.00  30.00  0.00  0.00  0.00 0.00e+000 0.00e+000
   2  2.16  0.20  1.00 150.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
   3  2.16  0.20  1.00 150.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
   4  2.16  0.20  1.00 150.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
   5  2.16  0.20  1.00 150.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
   6  2.16  0.20  1.00 150.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
   7  2.16  0.20  1.00 150.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
#
# END OF AVAL-1D INPUT FILE
# ========================

**********************************************
E N D   O F   A V A L - 1 D  ---  L O G F I L E
**********************************************
```

Figure 67: Dense flow log file.

6.3.2 Powder snow avalanche

- `SL-1D` Version
- Information about problem name and input file name.
- INPUT file.
- DUMP information.

```
SL-1D Version 0.5.11 log file
~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Problem name:               Albristhorn
Run name:                   vergleich3_1.2
Command file:               H:\Aval_1d\Update2001\Tests\Staublawine\vergleich3_1.2.ava


# AVAL-1D INPUT FILE
# SLF-PROGRAM FOR ONE-DIMENSIONAL AVALANCHE SIMULATIONS
# VERSION 1.2, November 2001
# ====================================================
#
| NAME AND INFORMATION
#
Track_Name Albristhorn
Run_Name vergleich3_1.2
#
INFO----------------------------------------
Input gemaess Schaetzungen aufgrund der
Begehung vom 01.02.1995.
----------------------------------------INFO
#
| DENSE FLOW GLOBAL PARAMETERS
#
Elem_Size                8.0
Dump_Interval            1.0
Max_Time                  65
Return_Period            300
Red_Blue_Limit          30.0
Blue_White_Limit         0.3
Rho                      300
Lambda                   2.5
Time_Step             0.0020
Endmark x           605875.0
Endmark y           148080.0
#
| POWDER SNOW GLOBAL PARAMETERS
#
Elem_Size              8.0
Dump_Interval          1.0
Max_Time                65
Region           Nordalpen
Return_Period          300
Max_Dev                8.0
Susp_Rate             0.20
Cell_Cut              8.00
#
Air_Density 1.0
Particle_Density 917.0
Gravity 9.81
Fluid_Viscosity 1.7e-05
Settling_Velo 1.0
#
C_mu 0.09
C1_eps 1.44
C2_eps 1.92
C3_eps 0.8
Sigma_c 1.0
Sigma_k 1.0
Sigma_eps 1.3
#
Velo_Prof_Coeff_0 1.4
Velo_Prof_Coeff_1 0.0
Velo_Prof_Coeff_2 -1.4
#
Conc_Prof_Coeff_0 1.3333
Conc_Prof_Coeff_1 -0.66667
Conc_Prof_Coeff_2 0.0
#
Turb_Prof_Coeff_0 1.0
Turb_Prof_Coeff_1 0.0
Turb_Prof_Coeff_2 0.0
#
Diss_Prof_Coeff_0 1.0
Diss_Prof_Coeff_1 0.0
Diss_Prof_Coeff_2 0.0
#
Threshold_Factor 10.0
Alpha 0.02
Beta_0 0.02
Beta_1 0.5
Beta_2 1.0
Beta_3 1.2
Beta_4 1.0
```

```
# Gamma_1 = PROF_VEL_0
# Gamma_2 = PROF_CONC_0
Gamma_3 2.0
Gamma_4 3.0
#
Max_Time_Step 0.2
Min_Salt_Height 0.1
Min_Salt_Velo 0.1
Max_Salt_Density 100.0
Min_Susp_Height 0.1
Min_Susp_Velo 0.1
Min_Susp_Turb 1.0e-06
Min_Susp_Dissip 1.0e-04
Courant_Nr 0.85
Relaxation_Factor 0.7
#
Min_Salt_Mass_Flux           8.0
Min_Salt_Mom_Flux            8.0
Min_Susp_Mass_Flux           8.0
Min_Susp_Mom_Flux            8.0
#
| COORDINATES
#
Number_of_Points        20
#
# No       X            Y          Z          W
   0    603975.000    149475.000  2700.000   100.000
   1    604100.000    149375.000  2600.000   200.000
   2    604200.000    149275.000  2500.000   350.000
   3    604300.000    149200.000  2400.000   500.000
   4    604400.000    149125.000  2300.000   450.000
   5    604516.000    149055.000  2207.000   310.000
   6    604525.000    149050.000  2200.000   300.000
   7    604625.000    149000.000  2100.000   150.000
   8    604750.000    148900.000  2000.000    50.000
   9    604800.000    148870.000  1900.000    50.000
  10    604900.000    148800.000  1800.000    50.000
  11    605100.000    148675.000  1700.000    50.000
  12    605400.000    148425.000  1600.000   150.000
  13    605750.000    148150.000  1520.000   750.000
  14    605875.000    148080.000  1530.000   750.000
  15    605902.000    148062.000  1540.000   750.000
  16    605931.000    148042.000  1550.000   750.000
  17    606150.000    147900.000  1600.000   750.000
  18    606500.000    147600.000  1700.000   750.000
  19    606925.000    147300.000  1740.000   500.000
#
#
| MONITORING POINTS
#
Monitoring Points           2
# Node Nr.               Name           Obs V  Obs H
   7                        Baumgrenze  23.5   4.5
  11                      Haus am Bach  16.6   2.5
#
| DENSE FLOW LOCAL PARAMETERS
#
# No    Mu    Xi      h    Rel  Canal Slope    Dist   Vel
   0  0.160  2500  1.0000   1     0   32.0     188.7  0.00
   1  0.160  2500  1.0000   1     0   35.3     173.2  0.00
   2  0.160  2500  1.0000   1     0   38.7     160.1  0.00
   3  0.160  2500  0.0000   1     0   38.7     160.1  0.00
   4  0.160  2500  0.0000   1     0   34.5     164.3  0.00
   5  0.160  2500  0.0000   1     0   34.2      12.4  0.00
   6  0.160  2500  0.0000   0     0   41.8     150.0  0.00
   7  0.160  2500  0.0000   0     0   32.0     188.7  0.00
   8  0.200  1750  0.0000   0     1   59.8     115.8  0.00
   9  0.200  1750  0.0000   0     1   39.3     157.8  0.00
  10  0.200  1750  0.0000   0     1   23.0     256.2  0.00
  11  0.160  2500  0.0000   0     0   14.4     403.1  0.00
  12  0.160  2500  0.0000   0     0   10.2     452.2  0.00
  13  0.160  2500  0.0000   0     0   -4.0     143.6  0.00
  14  0.160  2500  0.0000   0     0  -17.1      34.0  0.00
  15  0.160  2500  0.0000   0     0  -15.8      36.6  0.00
  16  0.160  2500  0.0000   0     0  -10.8     265.8  0.00
  17  0.160  2500  0.0000   0     0  -12.2     471.7  0.00
  18  0.160  2500  0.0000   0     0   -4.4     521.8  0.00
#
| POWDER SNOW LOCAL PARAMETERS
#
# No Rough Erodi  EroH EroRho SaltH  SaltV SaltD SuspH  SuspV  SuspD Turbulent  Dissipat
   0  0.00  0.24  0.00 180.00  1.05  0.00 200.00  0.00  0.00  0.00 0.00e+000 0.00e+000
   1  0.00  0.25  0.00 180.00  1.05  0.00 200.00  0.00  0.00  0.00 0.00e+000 0.00e+000
   2  0.00  0.26  0.00 180.00  1.05  0.00 200.00  0.00  0.00  0.00 0.00e+000 0.00e+000
   3  0.00  0.27  0.00 180.00  1.05  0.00 200.00  0.00  0.00  0.00 0.00e+000 0.00e+000
```

```
   4  0.00  0.28  0.00 180.00  1.05  0.00 200.00  0.00  0.00  0.00 0.00e+000 0.00e+000
   5  0.00  0.29  0.00 180.00  1.05  0.00 200.00  0.00  0.00  0.00 0.00e+000 0.00e+000
   6  0.00  0.30  0.30 180.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
   7  0.00  0.31  0.30 180.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
   8  0.00  0.32  0.30 180.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
   9  0.00  0.33  0.30 180.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
  10  0.00  0.34  0.30 180.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
  11  0.00  0.35  0.30 180.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
  12  0.00  0.36  0.30 180.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
  13  0.00  0.36  0.30 180.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
  14  0.00  0.36  0.30 180.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
  15  0.00  0.36  0.30 180.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
  16  0.00  0.36  0.30 180.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
  17  0.00  0.35  0.30 180.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
  18  0.00  0.35  0.30 180.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
  19  0.00  0.35  0.30 180.00  0.00  0.00   0.00  0.00  0.00  0.00 0.00e+000 0.00e+000
#
# END OF AVAL-1D INPUT FILE
# ========================
```

```
   form_factor:         S_CZ =  0.444
                         S_U =  0.933         S_CU =  1.011
                        T_UU =  1.045        S_CUU =  1.176
                        T_UK =  0.933        S_CUK =  1.011
                        T_UE =  1.045        S_CUE =  1.011
                     T_KKK_E =  0.999     S_CKKK_E =  0.000
                        T_KK =  1.000        S_CKK =  1.000
                     T_UKK_E =  0.933     S_CUKK_E =  1.011
                    T_UUKK_E =  1.045    S_CUUKK_E =  1.176
                  T_dUdUKK_E =  2.605  S_CdUdUKK_E =  2.172
                 S_dCdUUKK_E =  0.653
                     S_CKK_E =  0.999     S_dCKK_E = -0.666
                       T_UUK =  1.045       S_CUUK =  1.176
                     T_dUdUK =  2.613     S_CdUdUK =  2.178
                    S_dCdUUK =  0.653
                        S_CK =  1.000         S_dCK = -0.667
                      T_EE_K =  0.999       S_CEE_K =  0.999
```

```
Dump at t =   0.000 s,  dt = 0.2000 s,  cells 0--507.
Dump at t =   1.000 s,  dt = 0.2000 s,  cells 1--111.
Dump at t =   2.200 s,  dt = 0.2000 s,  cells 1--114.
Dump at t =   3.000 s,  dt = 0.2000 s,  cells 1--116.
Dump at t =   4.000 s,  dt = 0.2000 s,  cells 1--118.
Dump at t =   5.000 s,  dt = 0.2000 s,  cells 1--121.
Dump at t =   6.000 s,  dt = 0.2000 s,  cells 1--126.
Dump at t =   7.000 s,  dt = 0.2000 s,  cells 3--126.
Dump at t =   8.000 s,  dt = 0.2000 s,  cells 4--129.
Dump at t =   9.000 s,  dt = 0.2000 s,  cells 5--132.
Dump at t =  10.138 s,  dt = 0.1829 s,  cells 6--136.
Dump at t =  11.019 s,  dt = 0.1722 s,  cells 6--139.
Dump at t =  12.018 s,  dt = 0.1629 s,  cells 7--144.
Dump at t =  13.123 s,  dt = 0.1547 s,  cells 8--149.
Dump at t =  14.039 s,  dt = 0.1517 s,  cells 8--153.
Dump at t =  15.087 s,  dt = 0.1472 s,  cells 9--158.
Dump at t =  16.089 s,  dt = 0.1393 s,  cells 10--163.
Dump at t =  17.010 s,  dt = 0.1260 s,  cells 10--171.
Dump at t =  18.085 s,  dt = 0.1151 s,  cells 11--174.
Dump at t =  19.082 s,  dt = 0.1080 s,  cells 11--181.
Dump at t =  20.039 s,  dt = 0.1046 s,  cells 12--188.
Dump at t =  21.055 s,  dt = 0.0997 s,  cells 12--195.
Dump at t =  22.032 s,  dt = 0.0962 s,  cells 13--202.
Dump at t =  23.080 s,  dt = 0.0951 s,  cells 13--209.
Dump at t =  24.027 s,  dt = 0.0936 s,  cells 14--215.
Dump at t =  25.043 s,  dt = 0.0913 s,  cells 14--222.
Dump at t =  26.038 s,  dt = 0.0898 s,  cells 15--229.
Dump at t =  27.016 s,  dt = 0.0882 s,  cells 15--236.
Dump at t =  28.067 s,  dt = 0.0872 s,  cells 16--244.
Dump at t =  29.028 s,  dt = 0.0873 s,  cells 16--251.
Dump at t =  30.069 s,  dt = 0.0861 s,  cells 17--258.
Dump at t =  31.012 s,  dt = 0.0858 s,  cells 17--265.
Dump at t =  32.037 s,  dt = 0.0849 s,  cells 17--273.
Dump at t =  33.058 s,  dt = 0.0851 s,  cells 18--280.
Dump at t =  34.074 s,  dt = 0.0845 s,  cells 18--288.
Dump at t =  35.006 s,  dt = 0.0847 s,  cells 19--295.
Dump at t =  36.018 s,  dt = 0.0843 s,  cells 19--302.
Dump at t =  37.033 s,  dt = 0.0846 s,  cells 19--309.
Dump at t =  38.048 s,  dt = 0.0846 s,  cells 20--317.
Dump at t =  39.063 s,  dt = 0.0845 s,  cells 20--324.
Dump at t =  40.068 s,  dt = 0.0829 s,  cells 21--331.
Dump at t =  41.053 s,  dt = 0.0816 s,  cells 21--338.
Dump at t =  42.031 s,  dt = 0.0813 s,  cells 21--345.
Dump at t =  43.010 s,  dt = 0.0824 s,  cells 22--351.
```

```
Dump at t =  44.050 s,  dt = 0.0784 s,  cells 22--359.
Dump at t =  45.079 s,  dt = 0.0808 s,  cells 22--366.
Dump at t =  46.075 s,  dt = 0.0849 s,  cells 23--372.
Dump at t =  47.018 s,  dt = 0.0860 s,  cells 23--378.
Dump at t =  48.051 s,  dt = 0.0861 s,  cells 23--385.
Dump at t =  49.002 s,  dt = 0.0867 s,  cells 24--391.
Dump at t =  50.045 s,  dt = 0.0875 s,  cells 24--398.
Dump at t =  51.010 s,  dt = 0.0880 s,  cells 24--404.
Dump at t =  52.072 s,  dt = 0.0887 s,  cells 25--410.
Dump at t =  53.055 s,  dt = 0.0900 s,  cells 25--416.
Dump at t =  54.050 s,  dt = 0.0908 s,  cells 25--422.
Dump at t =  55.053 s,  dt = 0.0916 s,  cells 26--428.
Dump at t =  56.067 s,  dt = 0.0926 s,  cells 26--434.
Dump at t =  57.090 s,  dt = 0.0934 s,  cells 26--440.
Dump at t =  58.028 s,  dt = 0.0941 s,  cells 27--445.
Dump at t =  59.068 s,  dt = 0.0949 s,  cells 27--451.
Dump at t =  60.021 s,  dt = 0.0957 s,  cells 27--456.
Dump at t =  61.079 s,  dt = 0.0965 s,  cells 28--462.
Dump at t =  62.048 s,  dt = 0.0973 s,  cells 28--467.
Dump at t =  63.024 s,  dt = 0.0980 s,  cells 28--472.
Dump at t =  64.008 s,  dt = 0.0986 s,  cells 28--477.
Dump at t =  65.097 s,  dt = 0.0994 s,  cells 29--482.
SL-1D 0.5.11:  Run ‘vergleich3_1.2’ of problem ‘Albristhorn’ finished.
```

Figure 68: Powder snow log file.

6.4 Calculation of avalanche arms

Since version 1.2 it is possible to calculate reduction/addition of snow mass along the avalanche track. The reduction is very usefull to calculate avalanche arms, whereas the addition can be used to simulated several release areas.

- Problem:

  Your avalanche is dividing into two arms at altitude 1900 m a.s.l. A rough estimation shows that 70% of the release mass is going one way and 30% the other way.

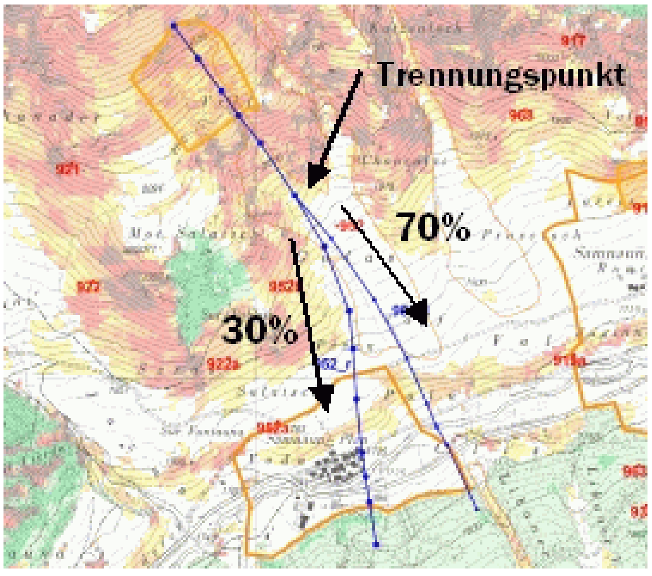


Figure 69: Two avalanche arms.

- Solution:

  Let’s have a closer look on the right avalanche arm (70%).

  1. Build the appropriate topographie, with 100% of release mass.

2. Then execute a normal simulation (*test.idl*).
3. Export the simulation from 1900 m a.s.l. with 70% of the total mass.
   Choose **Track Plot** → **Export...** → **Simulation** and the dialogue window in Figure 70 on the left pops up. Enter *0.7* at **Fraction of mass** (because 70% of the total mass is following this avalanche arm), *split* at **Output filename** and *1900* at **Altitude**. Then press **Export** and an information window appears that informs you about the details of this action, see Figure 70 on the right.

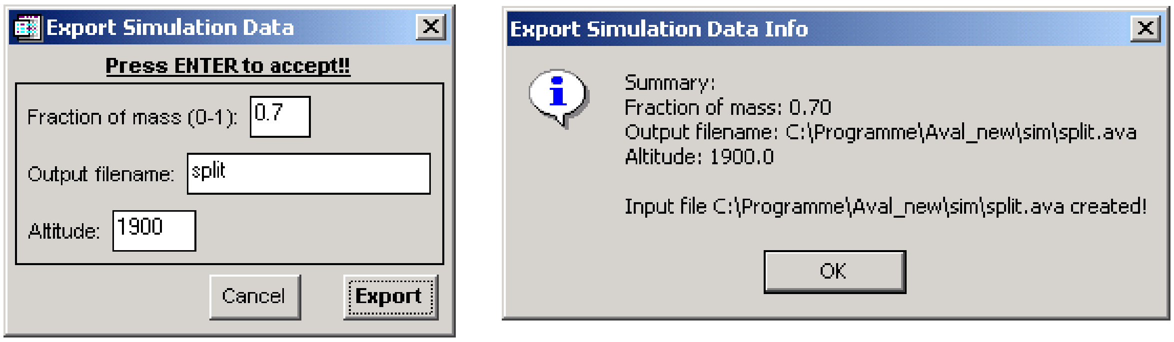


Figure 70: Left: export dialogue window; right: export information.

4. Close the current simulation *test.idl*.
5. Open the input file *split.ava*.
6. Rerun the calculation (*split.idl*) and overlay the result with your first simulation (*test.idl*).

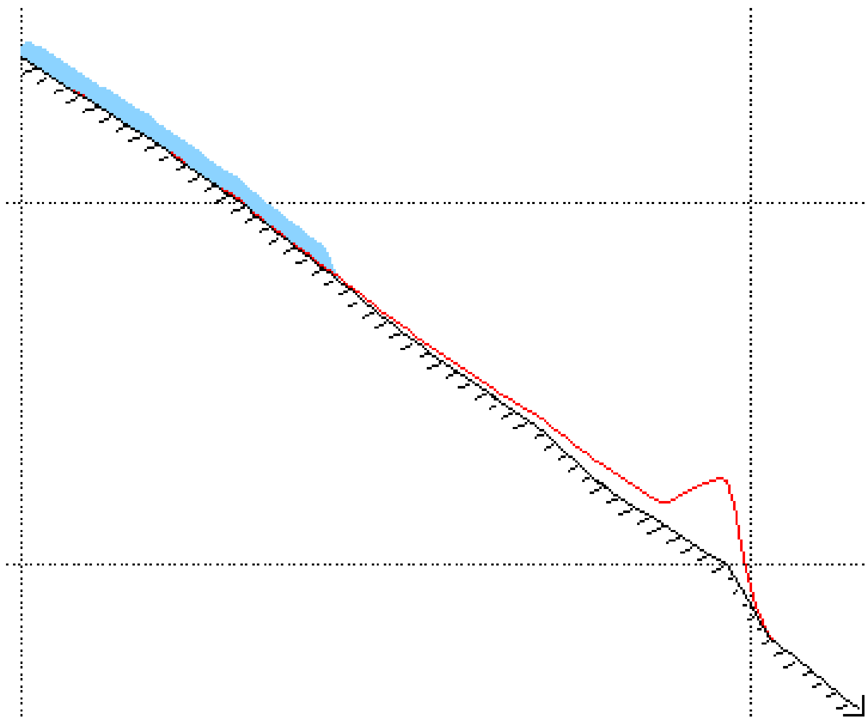


Figure 71: First simulation (*test.idl*, top left) and overlayed exported simulation (*split.idl*, bottom right) at time step t=0.

- What exactly happens when you export a simulation?

  AVAL-1D is looking for the time step at which the front of the avalanche arrives at 1900 m a.s.l. Figure 72 on the left shows the avalanche at time step t=24s. Most of the elements above altitude 1900 m a.s.l. have now a certain snow height and a corresponding velocity.

  These values are going to be written in a new input file (the snow height will be reduced by the chosen %). It is very important that the corresponding velocity is unchanged!! Below 1900 m a.s.l. the values from the original input file are being used (Figure 72 on the right shows the new input file).

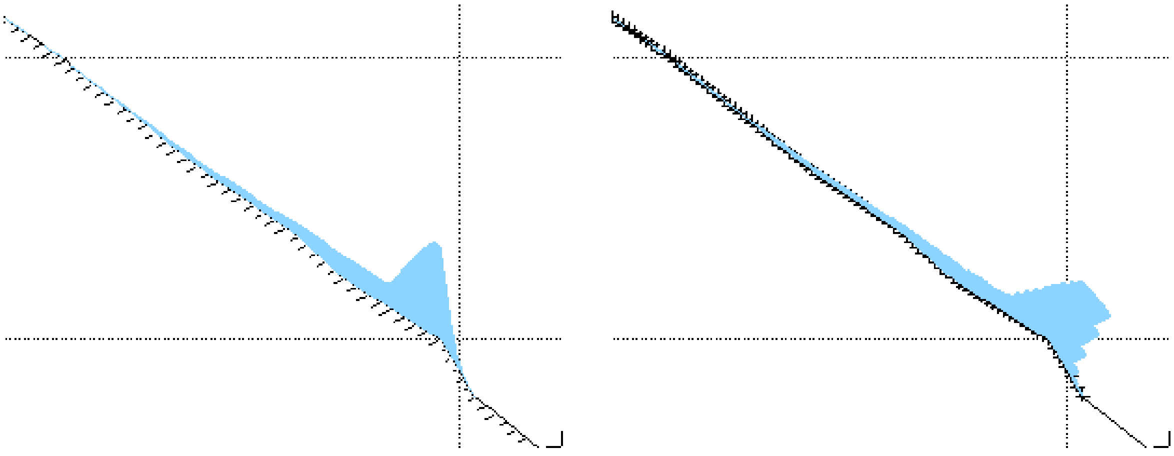


Figure 72: Left: snow height distribution at time step t=24s; right: *split.ava* input file.

A Example 'Samedan'

In order to facilitate your initiation with `AVAL-1D` we will lead you through an example of a calculation. This will allow you to become familiar with all the important functions and to use them. For this purpose we have chosen an example from *'Berechnung einer Fliesslawine, eine Anleitung f"ur Praktiker mit Beispielen' by Salm/Burkard/Gubler, Example Samedan*. The example file `samedan.ava` was copied into the `AVAL-1D` folder during the installation of the program.

The calculation example should provide solutions to the following issues:

- How to open an existing file or topography (p. 91).
- How to modify the topography (p. 94).
- How to edit the relevant dense flow and powder snow avalanche parameters (p. 97).
- How to modify the calculation parameters (S. 102).
- How to enter the control points (only dense flow avalanches) (p. 103).
- How to start a calculation (p. 104)?
- Which results can be displayed (p. 105)?
- How to export files and images (p. 123).

In the course of the example, small exercises are carried out to allow you to use the different functions directly.

A.1 How to open an existing file or topography

A simplified topography in Samedan was used for this example. Effective distances were used instead of coordinates. You will be able to verify the following xyz-coordinates and widths in the course of this example (see table 2):

With **Track** → **Open...** → **Input File** we can get to the dialogue window **Select Aval-1D Input File** (see figure 73).

With the filter (*.ava) all files are shown which can potentially be read in. Select `samedan.ava` with the mouse and then press 'OK'. Figure 74 shows `AVAL-1D`, after the `samedan.ava` example has been opened.

Table 2: (X,Y,Z) coordinates and widths (W) in (m).

Punkt	X	Y	Z	W
0	0.0	0.0	2340.0	160.0
1	0.0	417.0	2010.0	160.0
2	0.0	430.0	2000.0	160.0
3	0.0	610.0	1900.0	100.0
4	0.0	750.0	1830.0	60.0
5	0.0	1610.0	1710.0	60.0
6	0.0	1750.0	1690.0	60.0
7	0.0	1900.0	1670.0	60.0

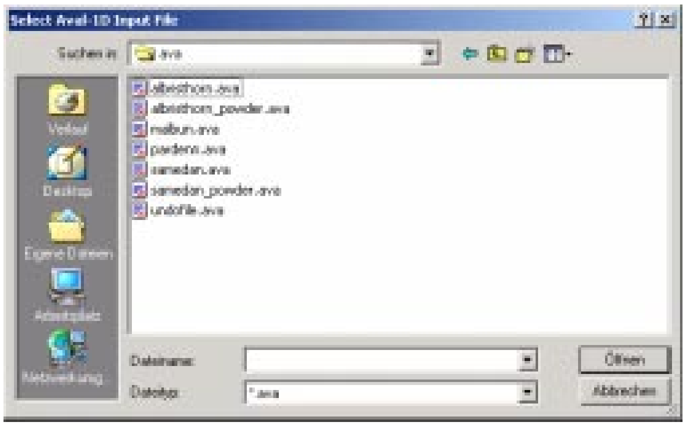


Figure 73: Dialogue window **Select Aval-1D Input File**: open a `INPUT` file.

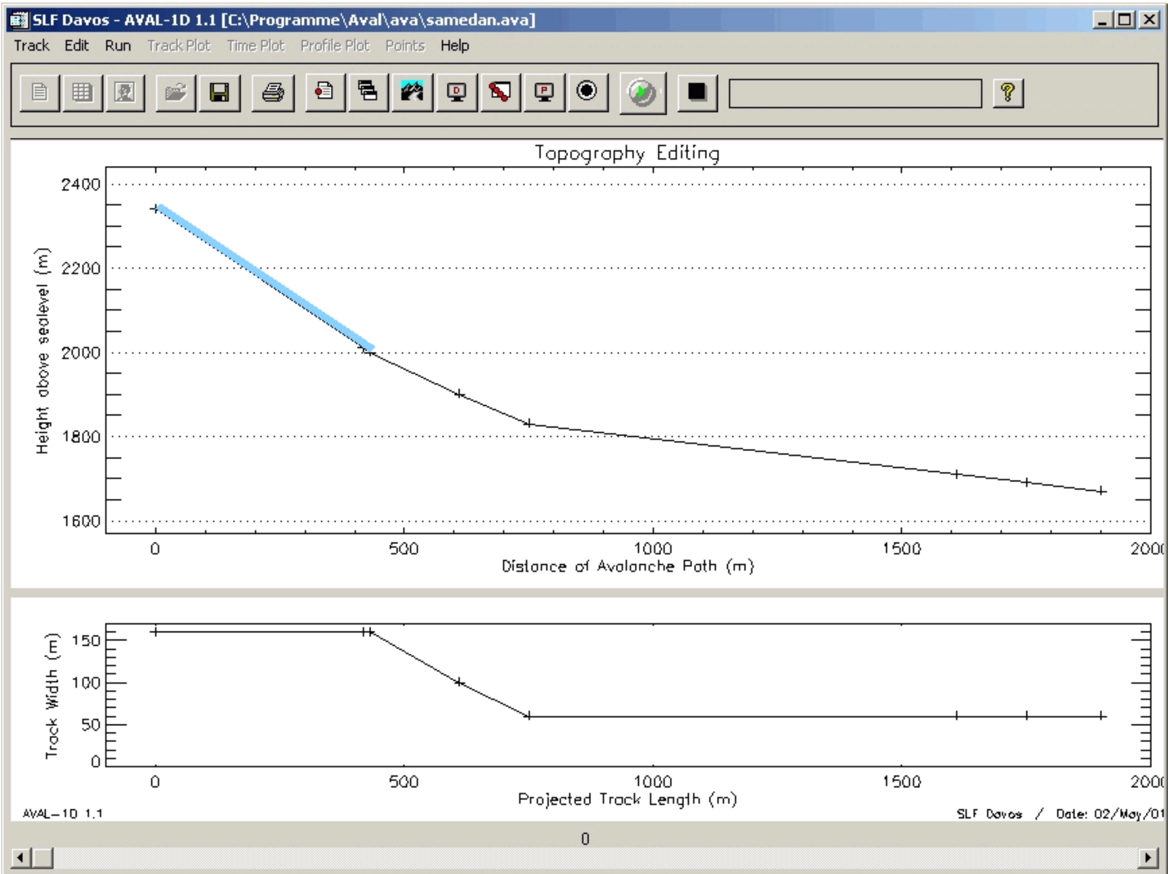


Figure 74: `samedan.ava` example displayed in `AVAL-1D`.

A.2 How to modify the topography

In the menu **Edit**, choose **Edit** → **Topography** which leads to the dialogue window **Edit Topography** (see figure 75). The arrows allow to jump from point to point and if necessary,

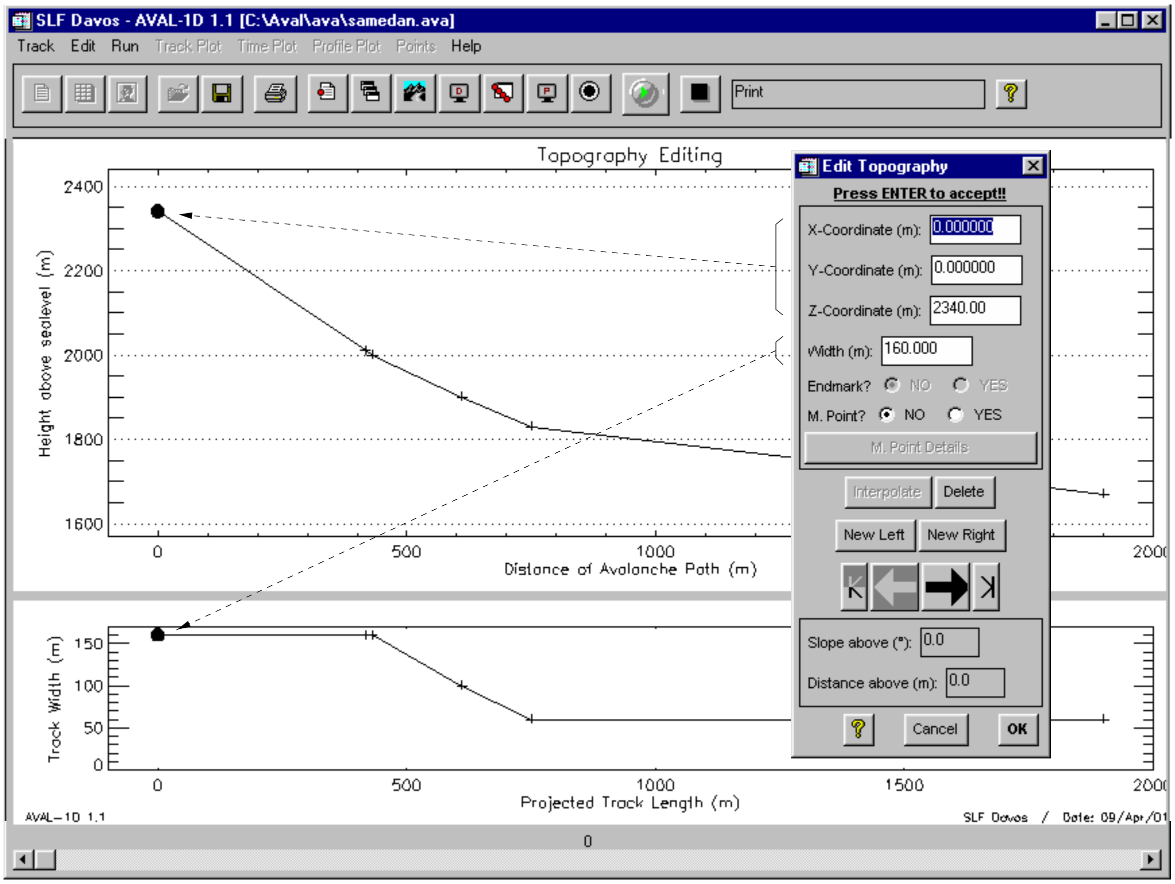


Figure 75: XYZ-dialogue window **Edit Topography**.

the X, Y, Z and W-values can be modified directly or in any case, they can be compared with table 2.

> **Exercise 1**
> We want to modify the Z-coordinate of the fifth point from 1830 to 2000 m. a.s.l. To do this, we use the arrows to reach the fifth point. Now press **ENTER** twice (the cursor will jump into the Z-coordinate field and the field will be marked automatically) and enter the new altitude of 2000 m. This new altitude is then adopted by pressing on **ENTER** again (see figure 76). This change is of course not realistic. Press **Cancel** in order to undo this change. The dialogue window closes and the change of height in point five is undone.

The X-coordinates, Y-coordinates and the width of the avalanche can be modified in the same manner for each point.

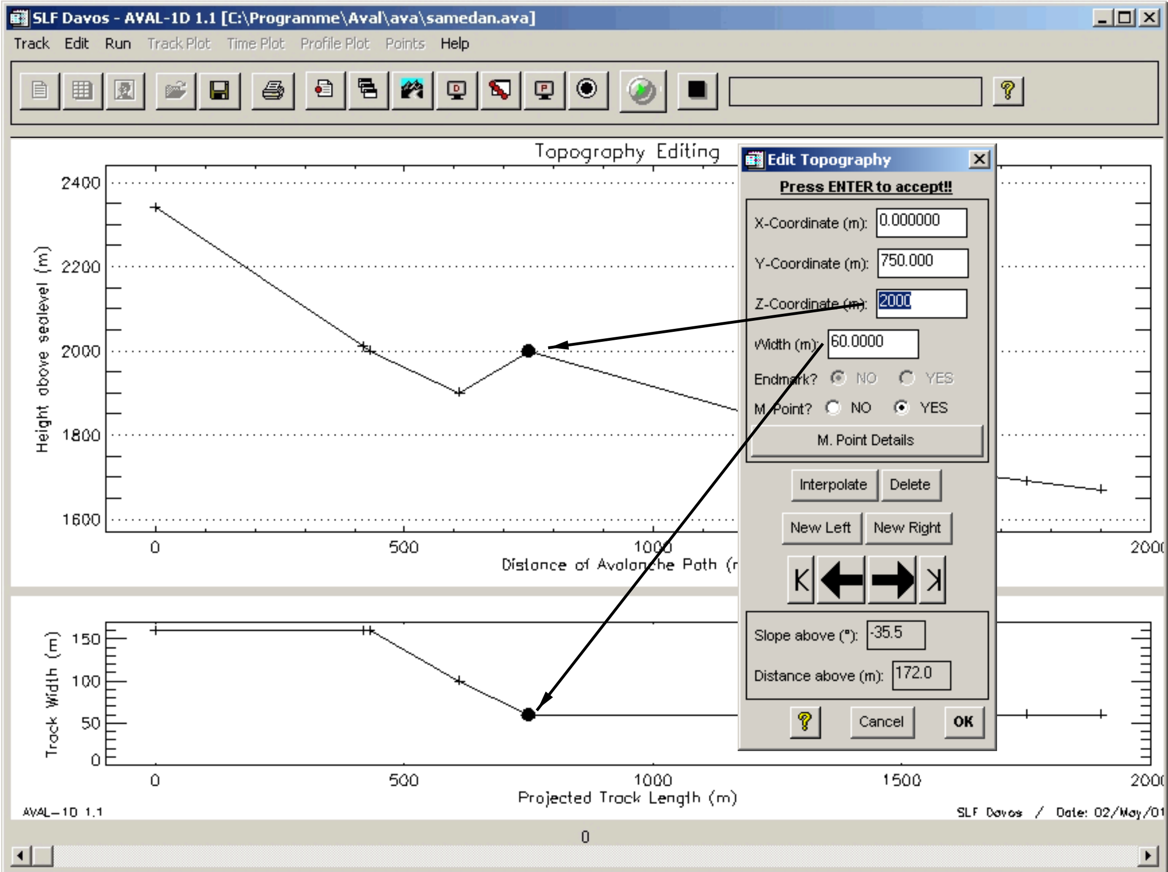


Figure 76: Display of the modified Z-coordinates

Further possibilities in the dialogue window **Edit Topography**:

- **Endmark**: allows to mark the end of the observed avalanche in order to be able to compare it with the calculated runout zone later. As you have probably noticed, it is not possible to select this function for most of the points. This is because another point has already been defined as the **Endmark** point in this example.

Exercise 2
This exercise consists of setting the **Endmark** to point 7. To do this, use the arrows and search the endmark point. As you will notice, it is now possible to select this function. Use the mouse to click on **NO** (as the **Endmark** should be moved to point 7), and use the arrows to move to point 7. Click on **YES** to set the **Endmark**. If you now use the arrows to jump to the other points, you will see that the function **Endmark** is disabled again.

- **Interpolate**: The **Interpolate** button contains two functions (see figure 77):
  - **Interpolate** allows to enter an additional point to the left, to the right, or on both sides of the selected point. To do this, click on **left**, **right** or **both**. Use **Rel. Distance** or **Height a.s.l.** to insert the point. The value **Rel. Distance** indicates the relative

distance between the additional point and the original point. With **Height a.s.l.** it is possible to directly specify the altitude of the point.

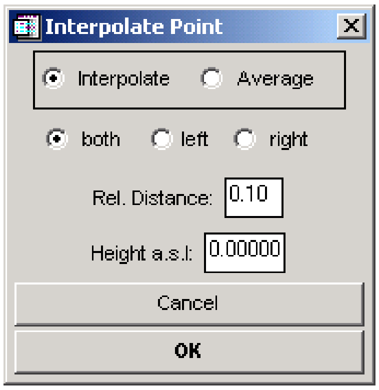


Figure 77: **Interpolate** dialogue window.

{ **Average** averages the selected point with the points lying to its left and to its right. When this function is selected, **left/right/both** and **Rel. Distance** become disabled.

Exercise 3
Add a point between points 3 and 4. Select point 4 and click on **Interpolate**. Then select **left** and enter 0.5 as **Rel. Distance**. If we enter 0.5 the additional point will be place exactly in the middle of point 3 and 4 (0.05 signify that the new point would be situated very close to point 4).

- **New Right**: by clicking here, a new point is inserted to the *right* of the marked point. This function is mainly used when a new topography is generated manually, when one point is entered after the other (see part 3.1.1, S. 35).
- **New Left**: this button allows to insert a new point to the *left* of the marked point.
- **Delete**: removes the currently selected point.
- **Cancel**: quits the dialogue window and is undoing any changes made since entering this dialogue window.
- **OK**: quits the **Edit Topography** dialogue window.

A.3 How to edit the relevant dense flow and powder snow avalanche parameters

The example `samedan.ava` consists of eight point, i.e. seven elements. The dense flow and powder snow avalanche parameters can be entered separately for each element.

> **!!! BEWARE !!!**
> The second, very small element is only needed for the powder snow avalanche calculation and is part of the fracture area. Without this small element, the snow height in the fracture area would decrease linearly to zero within the first element (i.e. `SL-1D` would then only calculate with half the mass). In this case, the fracture height decreases to zero in the second element!!

The first and second elements could be combined for a dense flow avalanche calculation (by removing the second point in **Edit** → **Topography**). Differences between dense flow and powder snow avalanche calculations become apparent for the first time during the choice of parameters (different parameters). In the menu **Edit** → **Avalanche Parameters...**, a choice can be made between **Dense Flow - Release Zone, Dense Flow - Xi/Mu** and **Powder Snow**:

- **Dense Flow - Release Zone**: Figure 78 shows the dialogue window **Departure Zone Parameters**. Four parameters can be edited there,

  - **Snowheight d0 (m)**: this is the mean fracture snowheight.
  - **Left Width (m)** and **Right Width (m)**: The avalanche width is specified punctually. Because we have a look at elements in this dialogue window, **Left Width (m)** indicates the avalanche width at the left ending (point) of the selected element, whereas **Right Width (m)** indicates the right ending (point) of the selected element.
  - **Density (kg/m^3)**: The density is constant throughout the whole simulation. It can be changed here or at **Edit** → **Calculation Parameters...** → **Dense Flow**.
  - **Total Release Volume (m^3)**: This field is only editable after clicking **Yes** at **Use Release Volume?**. Specify your release volume and `AVAL-1D` calculates the avalanche width according to the volume and the snowheight in the release area.

  The values can either be entered in the box created for this purpose or modified with the small **+** and **-** symbols, using the mouse. If your release zone contains four elements with 1.2 m of mean fracture height, jump to the fourth element (by using the arrows), enter the value 1.2 m at **Snowheight d0 (m)** and then click once on **This Element (Default)**, and **Elements to begin** in the pulldown menu which then appears. This gives each of the release elements 1.2 m of release snowheight.

  To the left and the right of the arrows the Z-coordinates of both points belonging to the element are shown. These boxes cannot be edited.

  The parameter entry process for dense flow avalanches is terminated with **OK**. By pressing **Cancel**, one quits the dialogue window and no changes are made.

- **Dense Flow - Xi/Mu**: Here the dense flow friction parameters are specified (see figure 79).

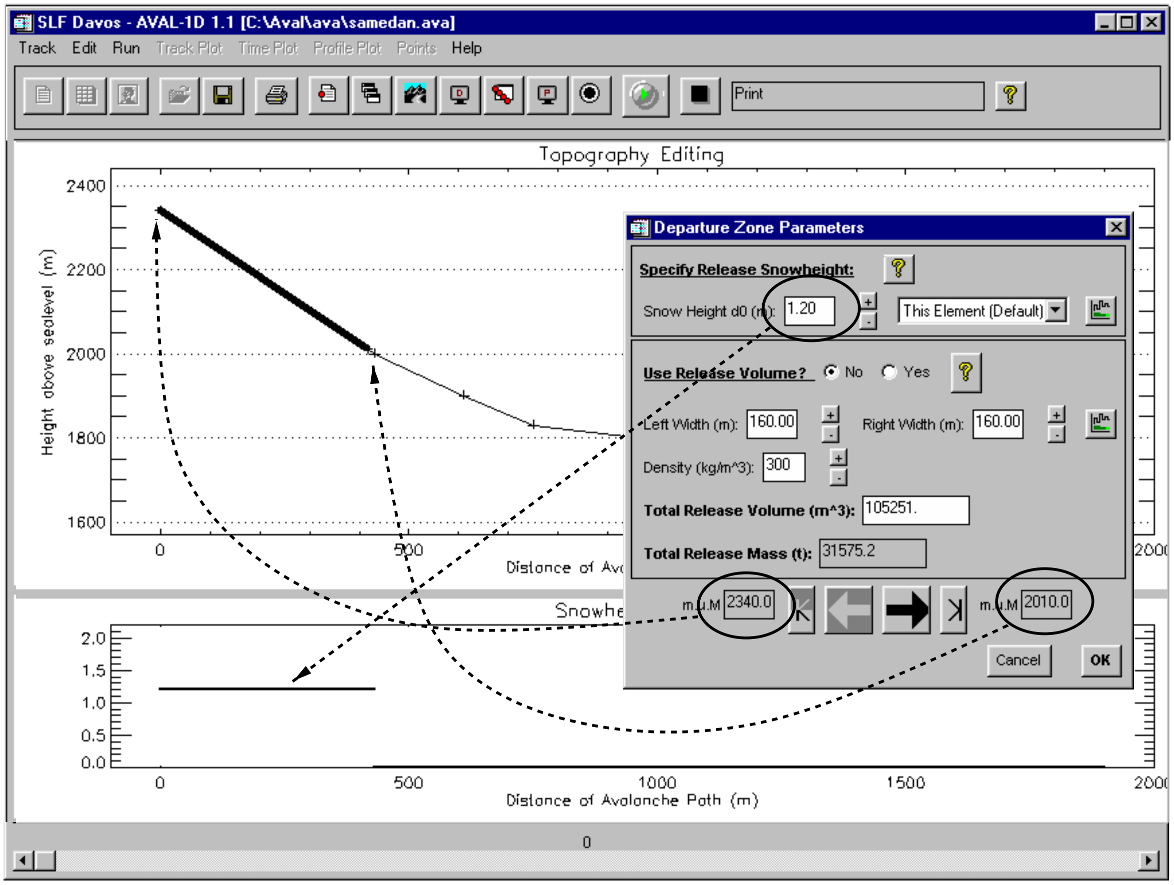


Figure 78: **Dense Flow - Release Zone** - dialogue window. The release conditions are specified.

Each parameter can be verified in the lower window. If the **Snowheight** value of an element is edited for example, the parameter is automatically displayed in the parameter window. It is not necessary to make an entry in order to control the values. By clicking on the little button on the left, the desired parameter is displayed.

{ ξ (m / s^2) (Factor of turbulent friction „Xi“),

{ μ ( ) (Factor of dry friction „Mu“),

The values can either be entered in the box created for this purpose or modified with the small **+** and **-** symbols, using the mouse. If one wants to use a ξ value of 2000 (m / s^2) for the whole topography, enter the value 2000 (m / s^2) at ξ **(m/s^2)** and then click once on **This Element (Default)**, and **All Elements** in the pulldown menu which then appears. This gives all of the elements a ξ value of 2000 (m / s^2).

To the left and the right of the arrows the Z-coordinates of both points belonging to the element are shown. These boxes cannot be edited.

The parameter entry process for dense flow avalanches is terminated with **OK**. By pressing **Cancel**, one quits the dialogue window and no changes are made.

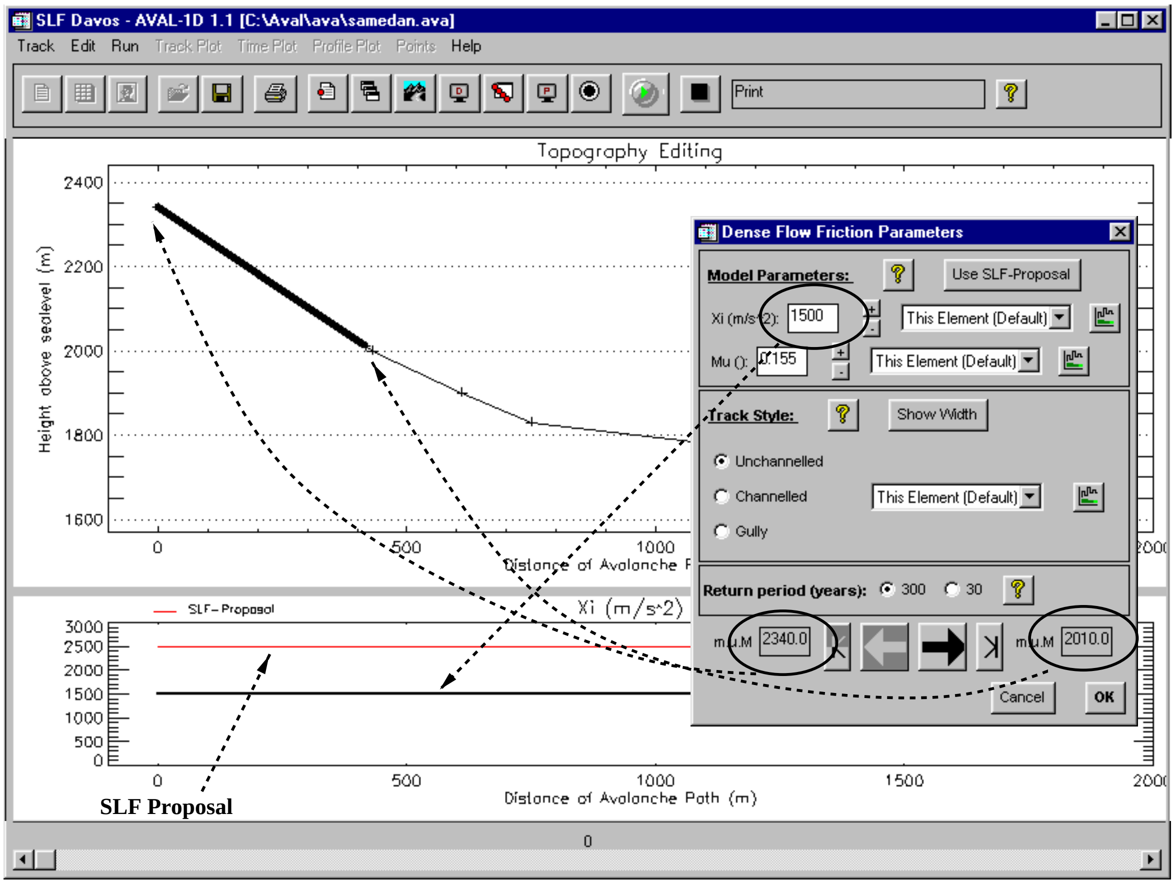


Figure 79: **Dense Flow - Xi/Mu** - dialogue window. Choice of dense flow friction parameters.

Each parameter can be verified in the lower window. If the μ value of an element is edited for example, the parameter is automatically displayed in the parameter window. It is not necessary to make an entry in order to control the values. By clicking on the little button on the right, the desired parameter is displayed.

- **Powder Snow**: Figure 80 shows the dialogue window **Powder Snow Avalanche Parameters Editing**. These parameters can be edited here,

  { Erodibility (m / s) (e),

  { Snowheight (m) (Height of Erodible Snow h1),

  { Density of Erodible Snow (kg / m^3) (d1),

  { Snowheight d0 (m) (Height of Saltation Layer h2),

  { Density of Saltation Layer (kg / m^3) (d2),

  { Suspension Rate (0-1): (s)

  { Return Period (years):

  { Region:

The process of entering parameters is exactly the same as for dense flow avalanches, see above. Using the arrows you can move from element to element and modify the parameters directly in the box or using the **+** and **-** symbols.

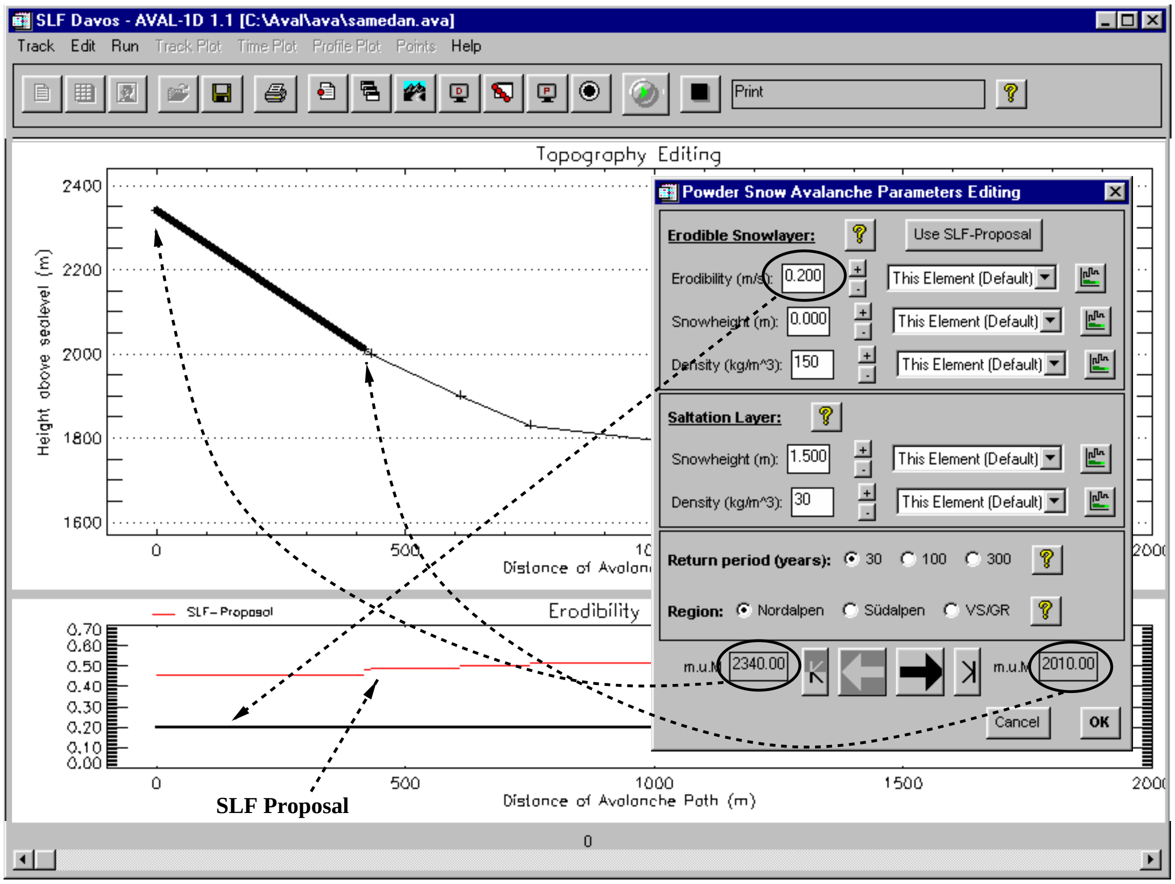


Figure 80: **Powder Snow Parameter Editing** - dialogue window

> **Exercise 4**
> Enter the dense flow and powder snow avalanche parameters from the tables 3 and 4 in order to be able to start the calculation example afterwards.

Table 3: Dense flow avalanche parameters. The second element contains the same parameters as the first and therefore belongs to the fracture zone.

Element	1	2	3	4	5	6	7
Xi	2500	2500	2500	2500	1750	1750	1750
Mu	0.16	0.16	0.16	0.16	0.2	0.2	0.2
Snowheight	1.2	1.2	0.0	0.0	0.0	0.0	0.0

Table 4: Powder snow avalanche parameters (for symbols see p. 99).

Element	1	2	3	4	5	6	7
e	0.46	0.48	0.49	0.5	0.52	0.52	0.52
h1	0.0	1.0	1.0	1.0	1.0	1.0	1.0
d1	150.0	150.0	150.0	150.0	150.0	150.0	150.0
h2	1.25	1.25	0.0	0.0	0.0	0.0	0.0
d2	180.0	180.0	0.0	0.0	0.0	0.0	0.0
v2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
h3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
d3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
v3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
s	0.2 (global parameter)						

A.4 How to modify the calculation parameters

Calculation parameters are parameters which apply to the whole calculation, such as time step, end time and calculation specific parameters. A differentiation is again made between dense flow and powder snow avalanches. In the menu **Edit** → **Calculation Parameters...** a choice can be made between **Dense Flow** and **Powder Snow**:

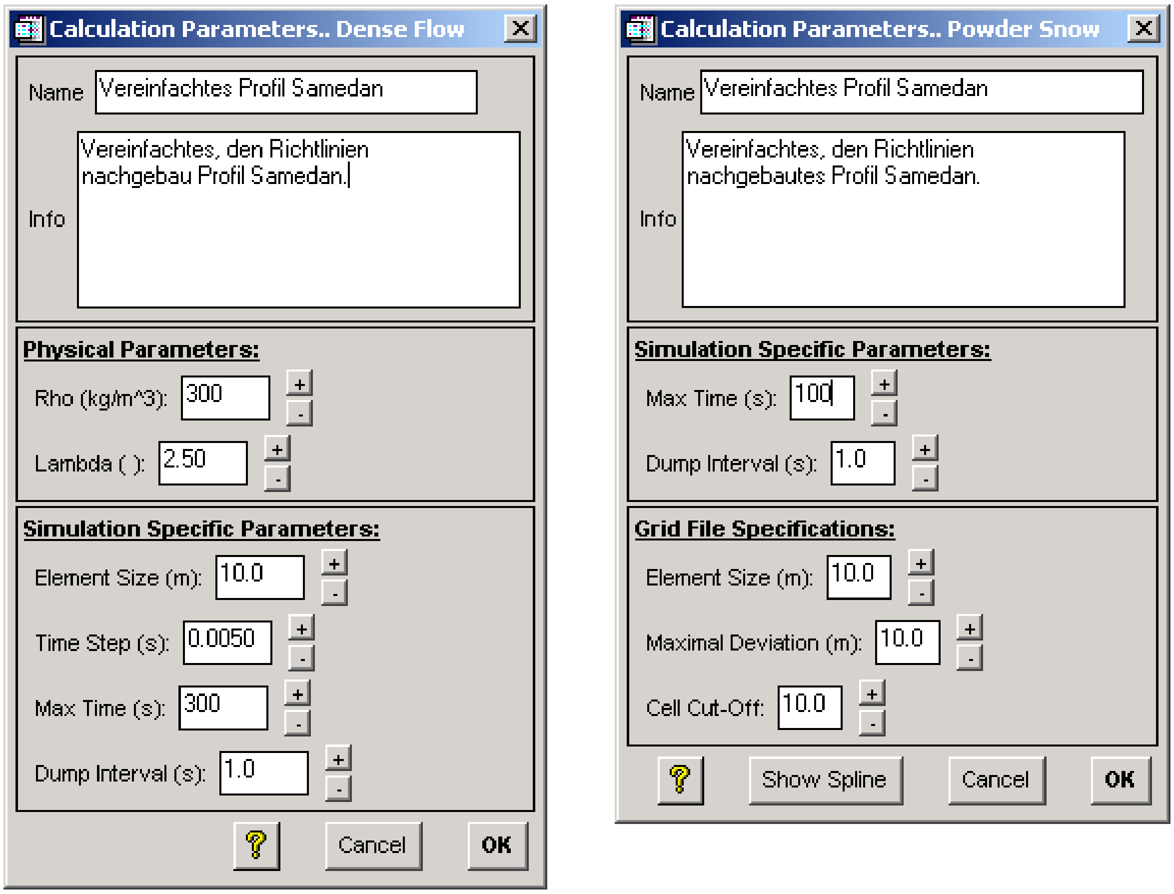


Figure 81: **Dense Flow and Powder Snow** - Calculation Parameters

- **Dense Flow**: Figure 81 (a) shows the dialogue window **Dense Snow Global Parameter Editing**. The following global parameters can be edited (see chapter 3.4.2, p. 50 for details):

  { Rho ρ (kg / m^3) (Density - a value of about 300 kg / m^3 is suggested),

  { Lambda λ ( ) (Factor of internal friction - usually around 2.5)

  { Element Size (m) (Size of the grid elements)

  { Time Step (s) (Time step),

  { Max Time (s) (End time)

  { and Dump Interval (s) (Interval at which the results are recorded).

- **Powder Snow**: Figure 81(b) shows the dialogue window **Powder Snow Global Parameter Editing**. The following global parameters can be edited (see chapter 3.4.2, p. 51 for details):

    { Max Time (s) (End time),

    { Dump Interval (s) (Interval at which the results are recorded),

    { Element Size (m) (Size of the grid elements),

    { Maximal Deviation (m)

    { and Cell Cut-Off

> **Exercise 5**
> Enter exactly the same values as in Figure 81, in order to be able to compare the results with the example results.

A.5 How to enter the control points (dense flow avalanches only)

In dense flow avalanche calculations it is possible to determine control points for which the results can be written in a log file. In this example, the log file would be called `samedan.dlg`. It can be displayed directly in `AVAL-1D` (**Track Plot** → **Show Logfile**), or printed (**Track Plot** → **Print Logfile**, as explained in chapter 5.1, p. 61).

To specify a monitoring point, choose **Edit Topography**, jump to the topography-point you want to set a monitoring point (with the arrows) and press **YES** at **M. Point ?**. A dialogue window appears (Monitoring Point Info, see figure 82, dialogue window on the right) where a name must be specified. Observed flowheights and flowvelocities can be specified as well, but not necessarily. The results of these points (flowheight and flowvelocity) will be written in a log file (together with general information such as chosen parameters, runout distances, etc.) and compared to the observed values (if specified).

You can get information about the monitoring points by choosing **Edit** → **Monitoring Point Info** or clicking the **Monitoring Point** Info-Button.

Required are:

- a control name (**Name**),
- **Observed Flowheight (m)**, is used as a comparison and must not necessarily be entered,
- **Observed Flowvelocity (m/s)**, is also used for comparison and must not necessarily be entered.

> **Exercise 6**
> Enter the control points in table 5.

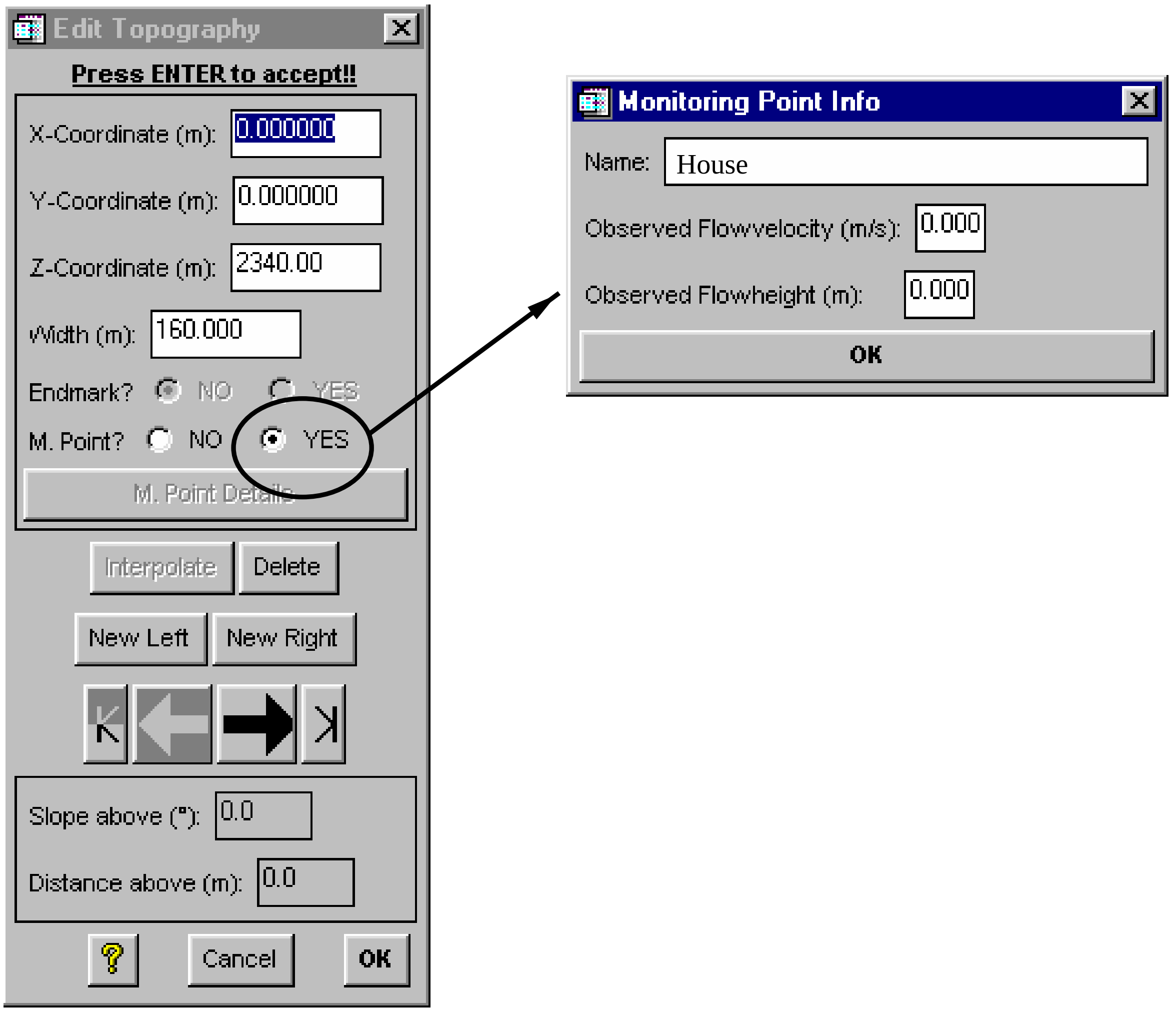


Figure 82: Dialogue window for entering control points

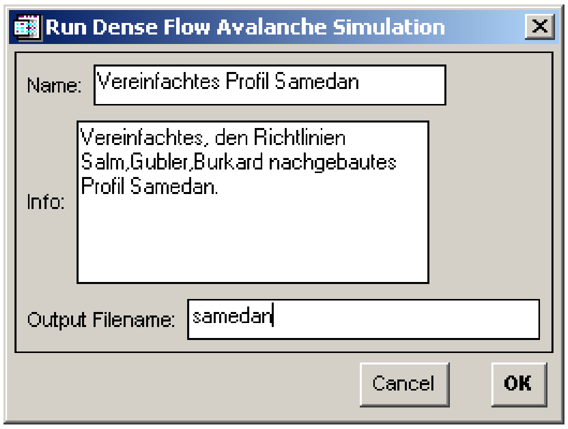
Table 5: **Monitoring Points**.

Entering ↓ / Control points →	1	2	3	4
Monitoring Point Name	Fracture	Track	Hut	Tree
Monitoring Point Height (m a.s.l)	2340.0	2000.0	1830.0	1710.0
Observed/estimated Flowheight (m)	1.3	1.3	2.5	3.5
Observed/estimated Flowvelocity (m/s)	15.0	21.0	25.0	19.0

A.6 How to start a calculation

When the local dense flow and powder snow avalanche parameters, the calculation parameters and the control points for dense flow avalanches have been entered, a calculation can be started. Select the menu **Run**, and then either **Dense Flow Simulation** or **Powder Snow Si-**

mulation. The dialogue windows **Run Dense Flow Avalanche Simulation** and **Run Powder Snow Avalanche Simulation** are shown in figures 83 (a) and (b).



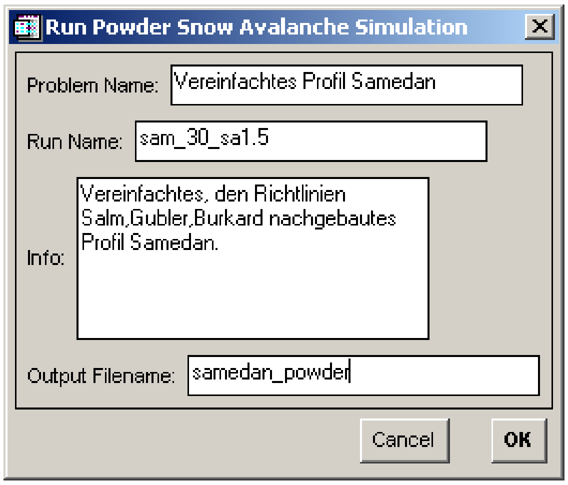


Figure 83: a) **Run Dense Flow** dialogue window; b) **Run Powder Snow** dialogue window.

Exercise 7 Enter the same file names as in figures 83 (a) and (b).

The **Run Name** in figure 83 (b) is a suggestion of how a simulation could be characterised and stands for: **sam** → samedan, **30** → return period of 30 years, **sa1.5** → saltation height of 1.5 m. The simulation results are shown in `AVAL-1D` after the calculation (the `INPUT`mode automatically changes to the `DENSE FLOW` or `POWDER SNOW` mode).

A.7 Which results can be displayed?

To see results it is necessary to have opened a result file (`*.idl` or `*.idp`). This is possible when you have effected a calculation, as `AVAL-1D` automatically displays the results file. For more information on the results mode, see chapter 5.

To start an animation, press the toolbar button (see button to the right). It is the same button you press in the `INPUT`-mode to start a calculation.

A.7.1 Dense flow avalanche

Open the example *samedan.idl*.

Animated display of the evolution of snow height, velocity and pressure:

Click on the **Animation**-button and see what happens. The dense flow avalanche flows along the topography. The same can be done with the velocity and the pressure, using **Track Plot** → **Velocity** or **Track Plot** → **Pressure**. You can also scale the snow height, velocity and pressure. Use the right mouse button to change the scaling.

Exercise 8
Try displaying the snow height with an exaggeration of 32 times and animating it. To do this, select **Edit** → **Scaling...** → **Change Scaling** (or use the right mouse button). A dialogue window pops up (**Change of actual scaling**). Replace the current value with 32 and click on **OK** (see figure 84). To start an animation, click on the **Animation**-button. The same can be tried with the velocity and the pressure. The chosen scaling factor can be saved by clicking **Save Factor** in the **Change of actual scaling**-dialogue window.

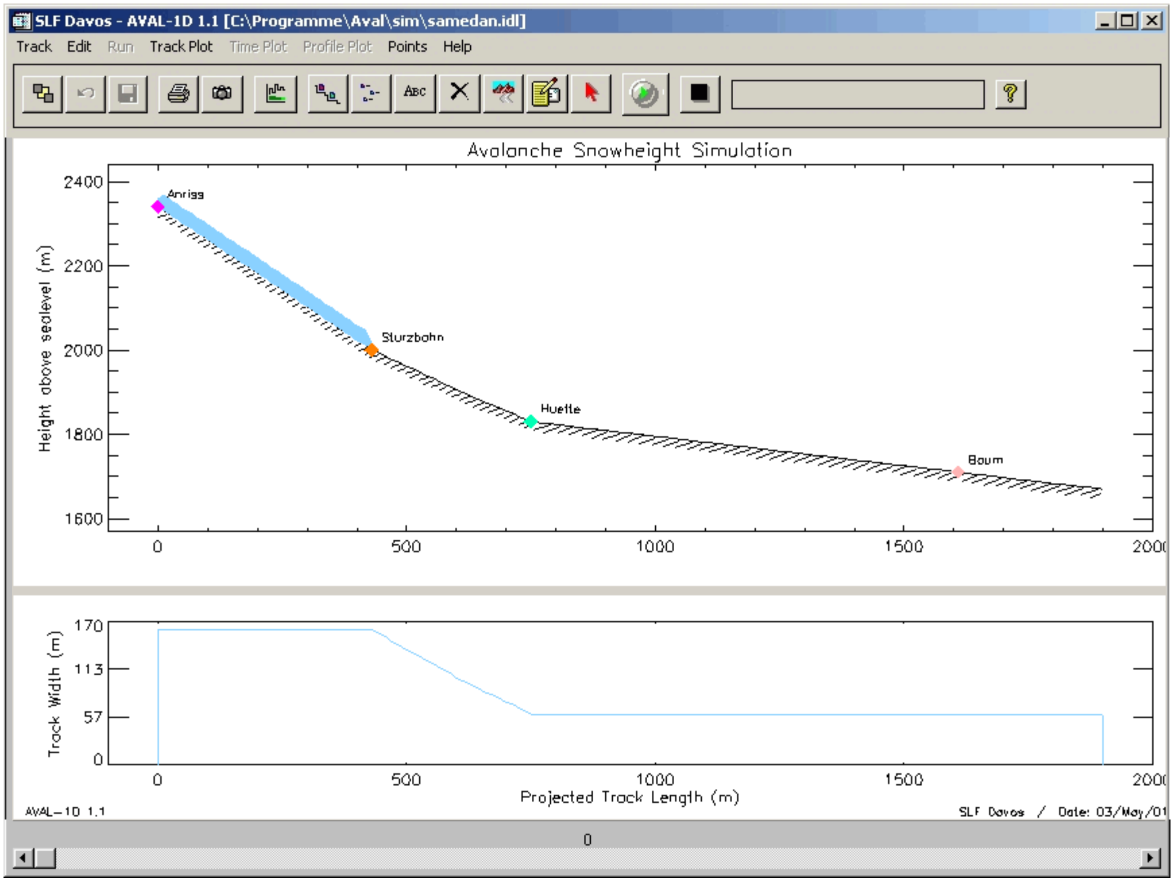


Figure 84: Display of snow height, increased 32 times. The monitoring points used are also shown and labeled.

Display of the maximum snow heights, velocities and pressures along the avalanche profile: These functions are simply laid over the current display. The position of the time step bar does not have any influence on these results.

- **Track Plot** → **Max Snowheight:** Using this function, the maximum snow height can be laid over the topography. Figure 85 shows what this display should look like. The snow height is still exaggerated 32 times at the time point t=0 (Time step bar at beginning). The image can be scaled using the command **Edit** → **Scaling...** → **Change Scaling**.

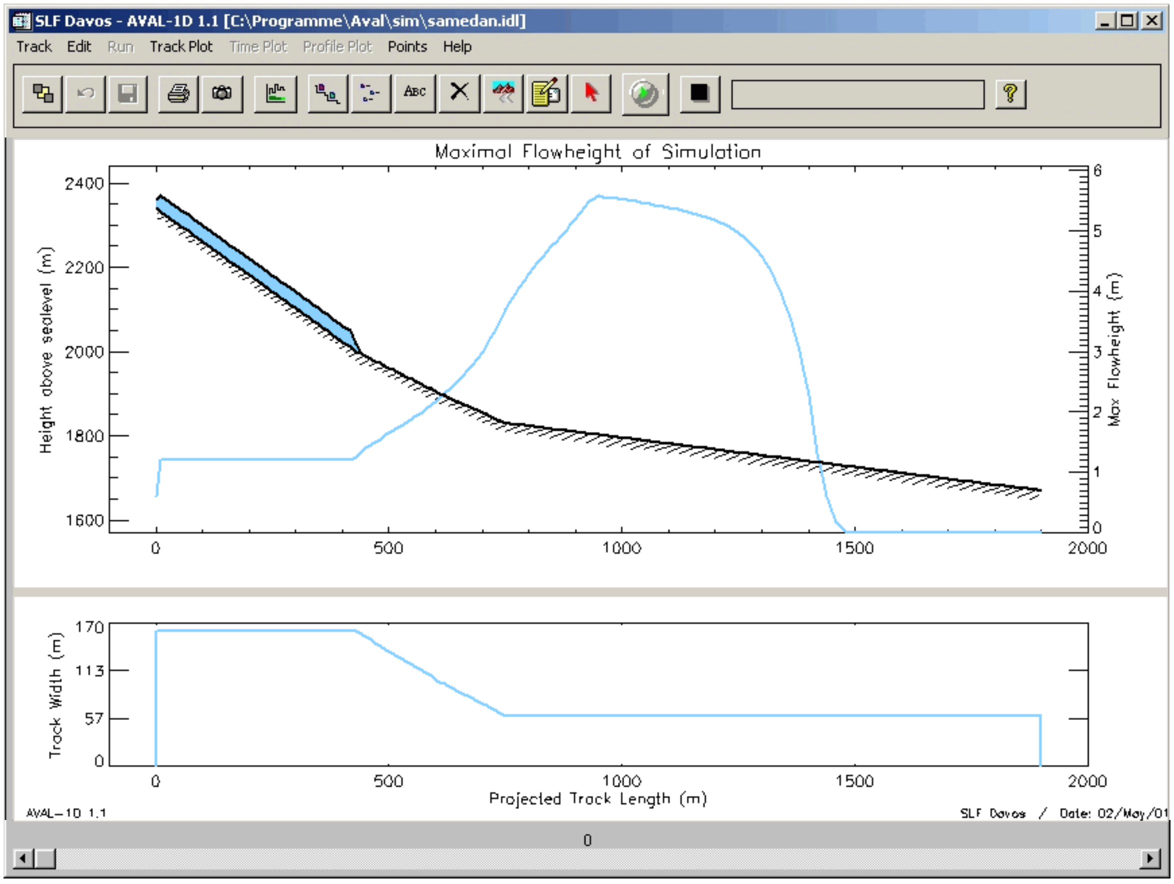


Figure 85: Maximum snow height along the topography. The snow height is shown with an exaggeration of 32 times (at the time t=0 s).

- **Track Plot** → **Max Velocity:** If you want to display the maximum velocity, Figure 86 should appear on your screen. This display can also be scaled using **Edit** → **Scaling...** → **Change Scaling**.
- **Track Plot** → **Max Pressure:** This function displays the development of maximum pressure. The 30 kPa pressure limit is also shown (see Figure 87). The **Endmark** is also shown in this Figure, which can be enabled and disabled with **Track Plot** → **Endmark On/Off**.

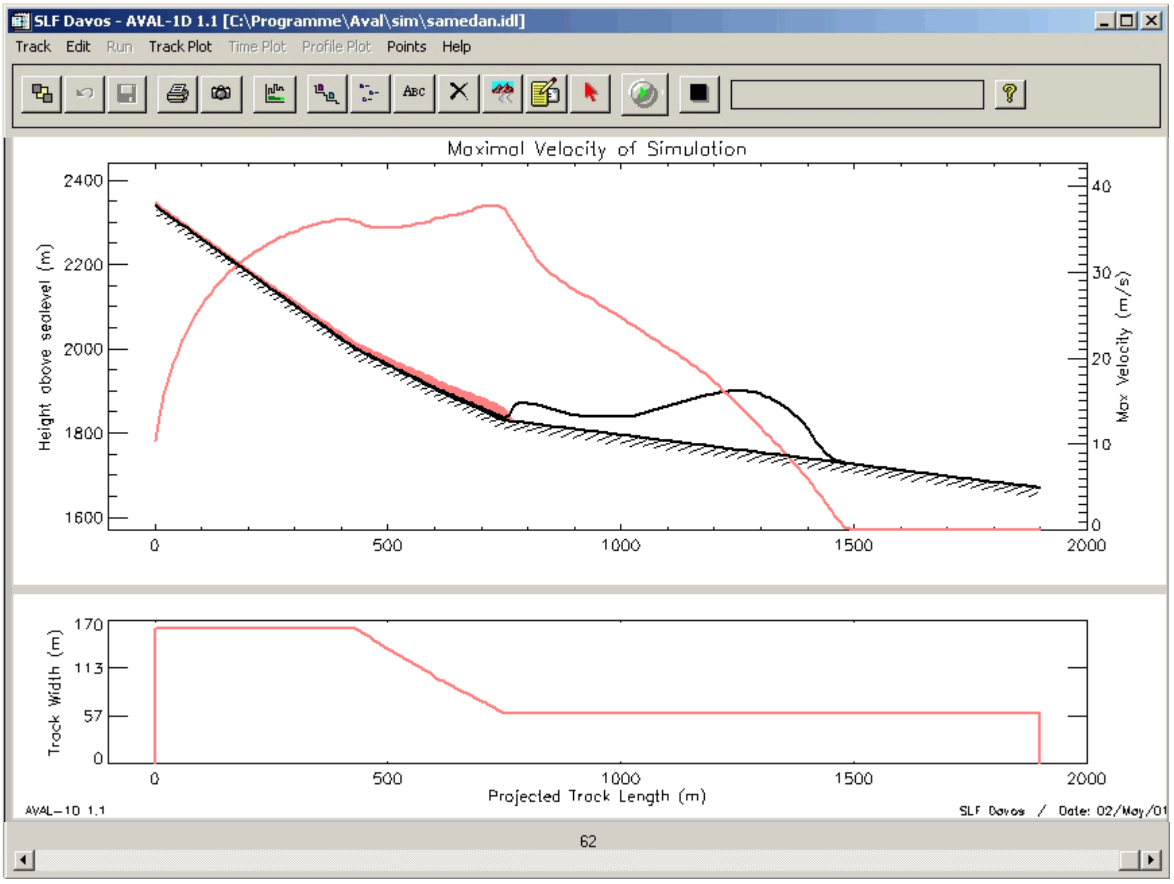


Figure 86: Maximum velocity along the topography. The snow height is exaggerated 32 times (at the time t=62 s).

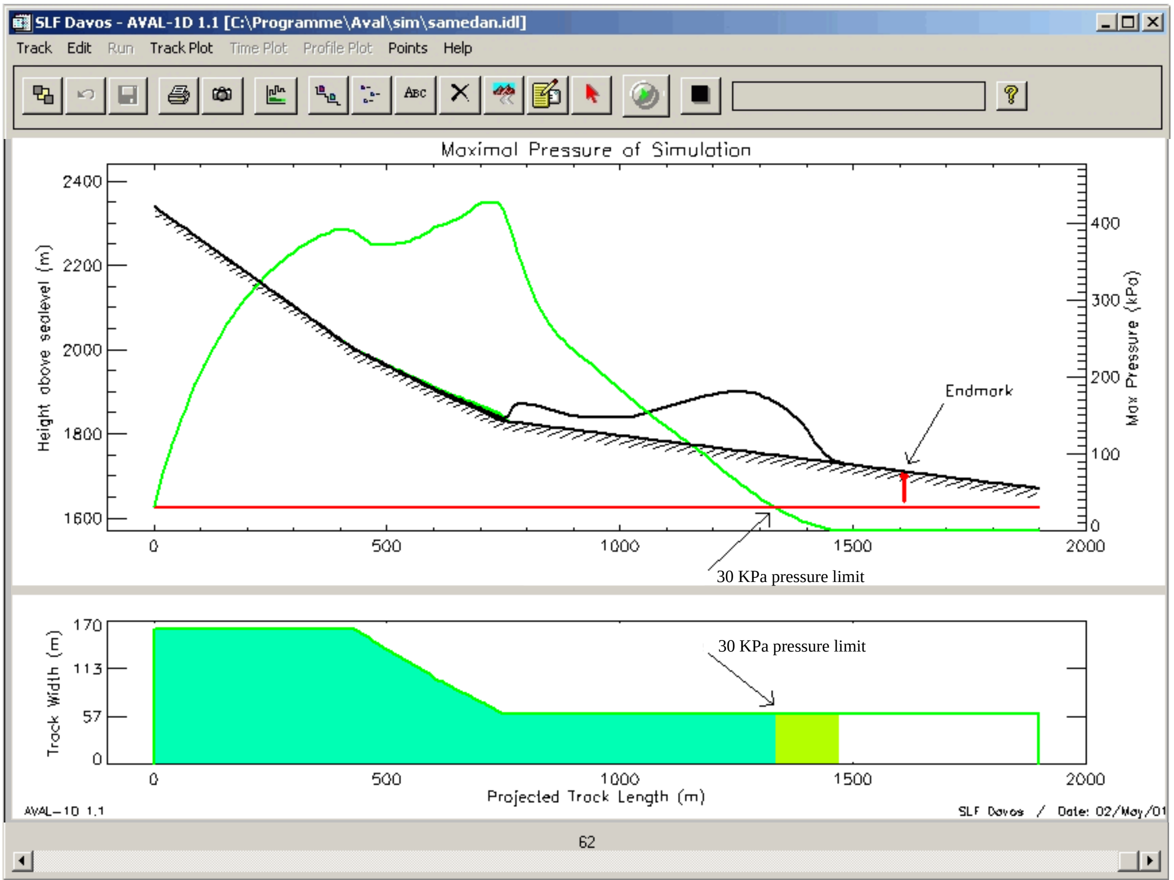


Figure 87: Development of maximum pressure along the topography. Snow height is exaggerated 32 times (at the time t=62 s).

Time Plots of snow height, velocity and pressure for given points: The Time Plots are displayed in a separate window. Points must first be selected along the topography, before one of the Time Plot functions can be applied.

Exercise 9
The development of velocity is to be displayed in the Time-Plots window for the four control points (2340, 2000, 1830 and 1710 m. a.s.l.). Click on **Points** → **Select Monitoring Points**. Then choose **Time Plot** → **Velocity** - the development of velocity for the four points is shown, see figure 88.

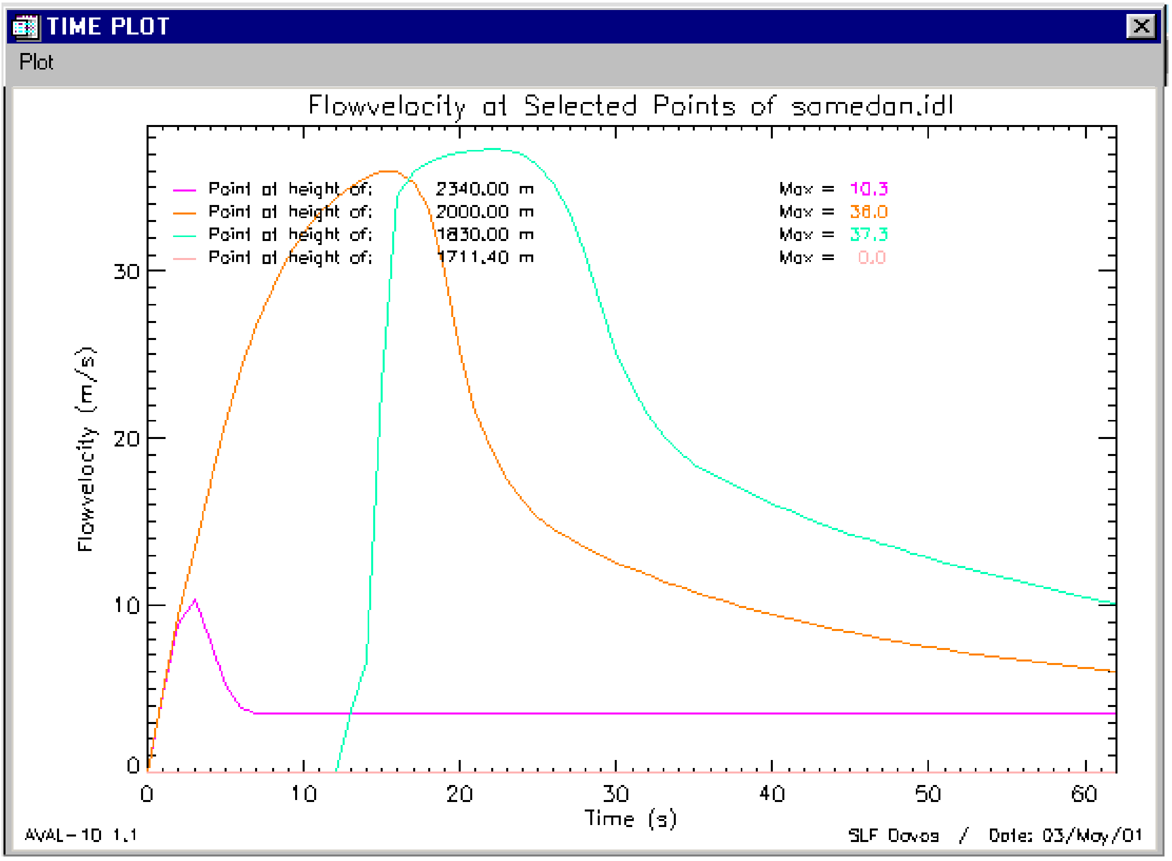


Figure 88: Development of velocity at the four control points (2340, 2000, 1830 and 1710 m. a.s.l.).

Log file: The most important results are written in a log file during a dense flow avalanche simulation. Before starting the simulation, you defined an **Output File** name. This name is also used for the log file, with the ending `*.dlg`. The log file for this example is shown in figure 68, p. 87.

A.7.2 Powder snow avalanche

Open the example *samedanPowder.idp*.

Display and animation of powder snow avalanche layers: After the calculation, `AVAL-1D` automatically displays the result file (see figure 89). The powder snow avalanche layers are laid over the topography in the topography window and are projected onto a horizontal surface in the parameter window. The scale in Figure 89 helps to estimate the size relationships. Normally, this scale is not shown, see chapter 6.2 p. 73 on how to activate the snow layer scale. Figure 90 shows this image more precisely (**Track Plot** → **Topography On/Off** was enabled). On the positive y-axis the three layers (erodible snow layer, saltation layer and suspension layer) are shown 1:1, whereas on the negative y-axis only the erodible snow layer and the saltation layer (increased 10 times) are shown.

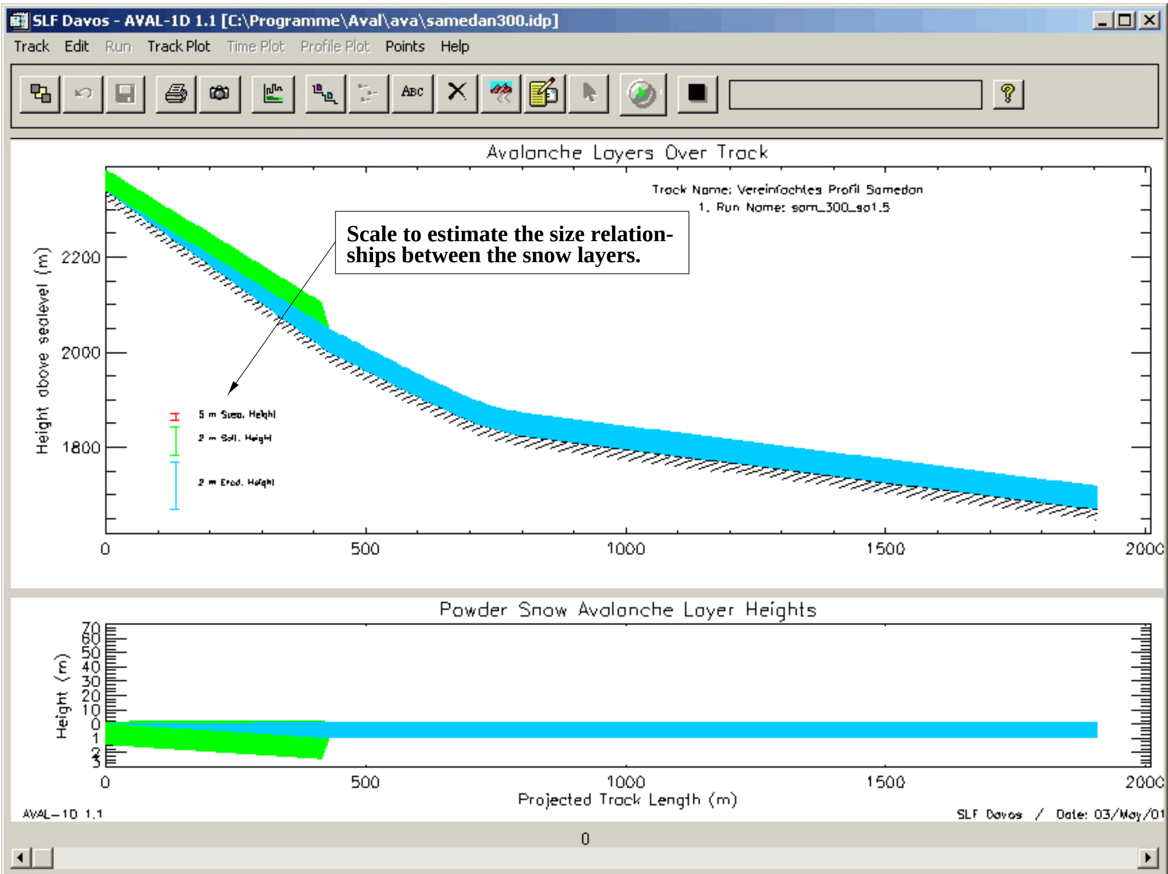


Figure 89: `samedan example.idp` after opening it in `AVAL-1D`.

Click on the **Animation**-button and let the powder snow avalanche flow along the topography into the valley. If you then click the right mouse button in the parameter window and choose **Max Values**, you should obtain the same image on your screen as that shown in figure 91 (you may have to click on **Track Plot** → **Topography On/Off** again, in order to get to the normal display). **Max Values** means that the maximum values for each point in a simulation are shown.

The powder snow avalanche layers can of course be scaled in the topography window

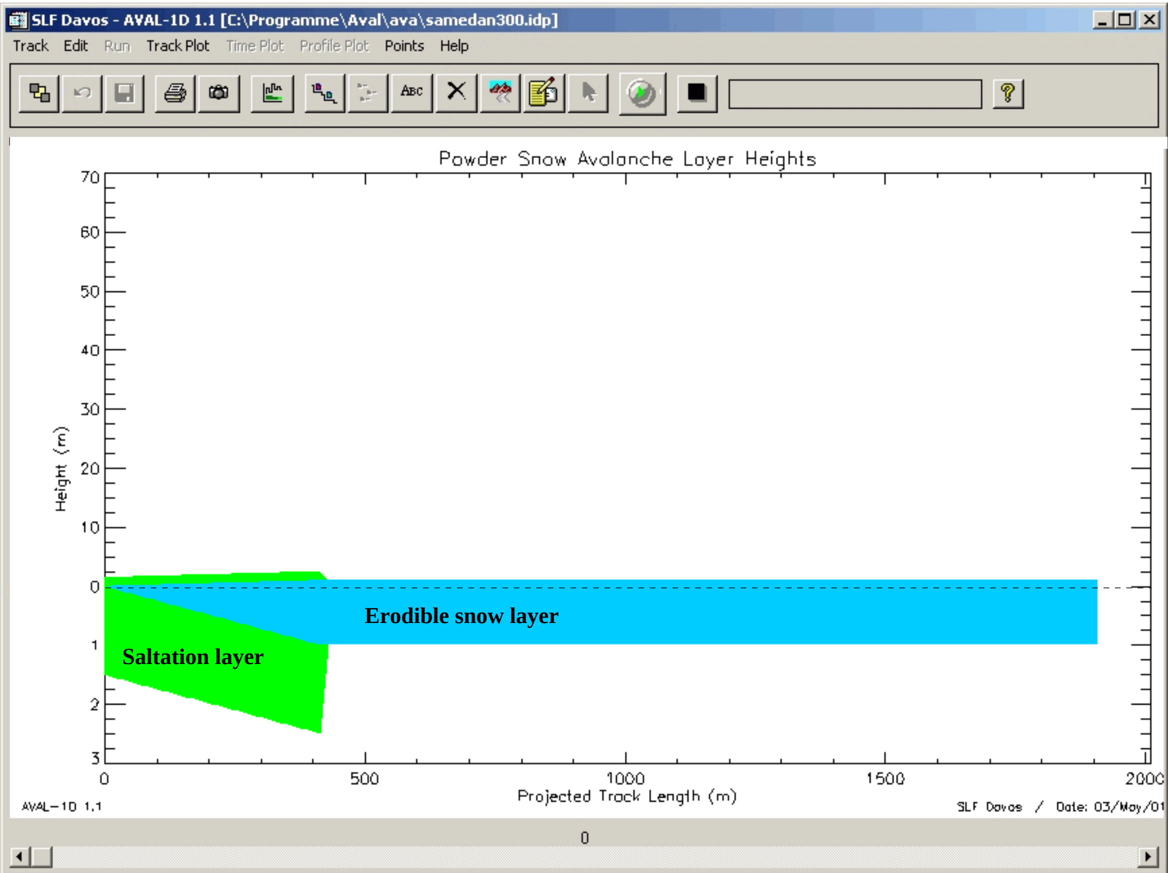


Figure 90: The powder snow avalanche layers are shown in projection in the parameter window (enlarged). At the time t=0s there is not yet a suspension layer on the positive y axis The negative y axis shows the erodible snow layer and the saltation layer (exaggerated 10 times).

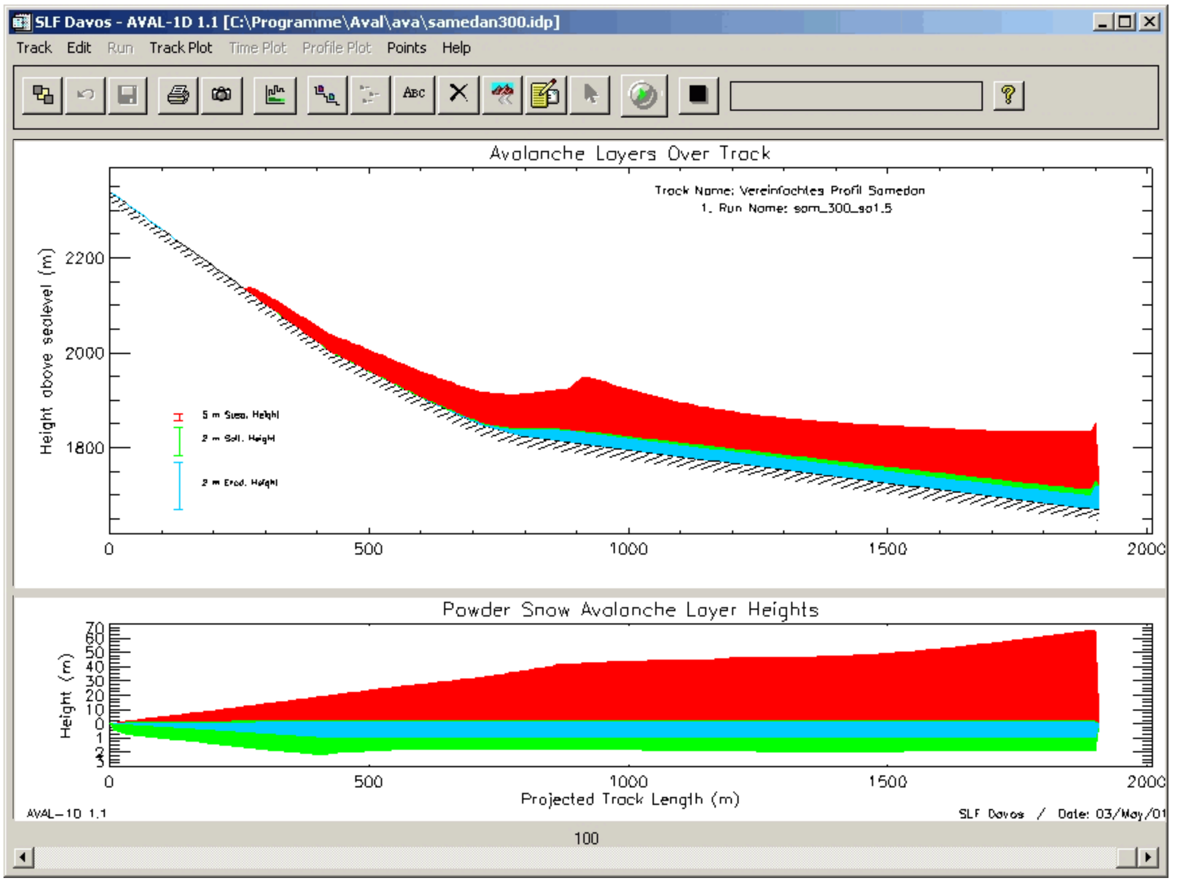


Figure 91: Powder snow avalanche at the time point t=100s; **Max Values** was also enabled in order to display the maximum values of a simulation in the parameter window.

and in the parameter window. Using **Edit** → **Scaling...** → **Avalanche Layers (Top Display)**, the scaling factor of each of the three layers can be modified in the topography window (see figure 10, p. 17, in the middle). The positive and negative y-axes can be scaled separately in the parameter window. In addition, it is possible to display only the erodible layer in the parameter window (by choosing **Yes** at **Show only erodible layer?**, see figure 10, p. 17, on the left).

Exercise 10
We would like to investigate the development of the erodible snow layer. To do this, click on **Track Plot** → **Topography On/Off**, in order to display the parameter window only. With **Edit** → **Scaling...** → **Scaled Layers (Bottom Display)** you reach the dialogue window (**Bottom plot scaling**), shown in figure 92. Enter the same values, answer the question '**Show only erodible layer?**' with **Yes** and then click on **OK**. Now only the erodible snow layer should be displayed in the parameter window (see figure 92). You can move the time step bar with the mouse and observe the decrease of the erodible snow layer in the process. Figure 93 shows the erodible snow layer at the time t=100s.

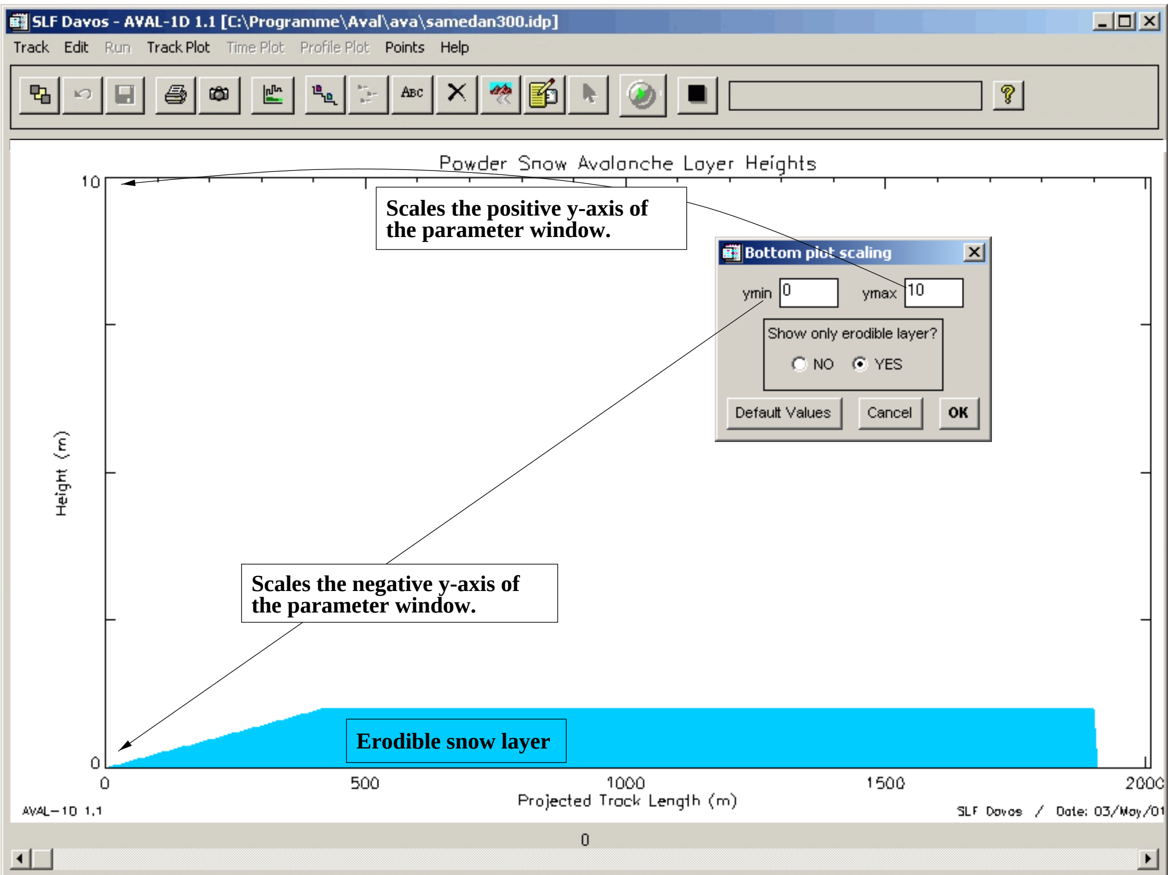


Figure 92: Erodible snow layer at the time t=0 s, shown in the enlarged parameter window.

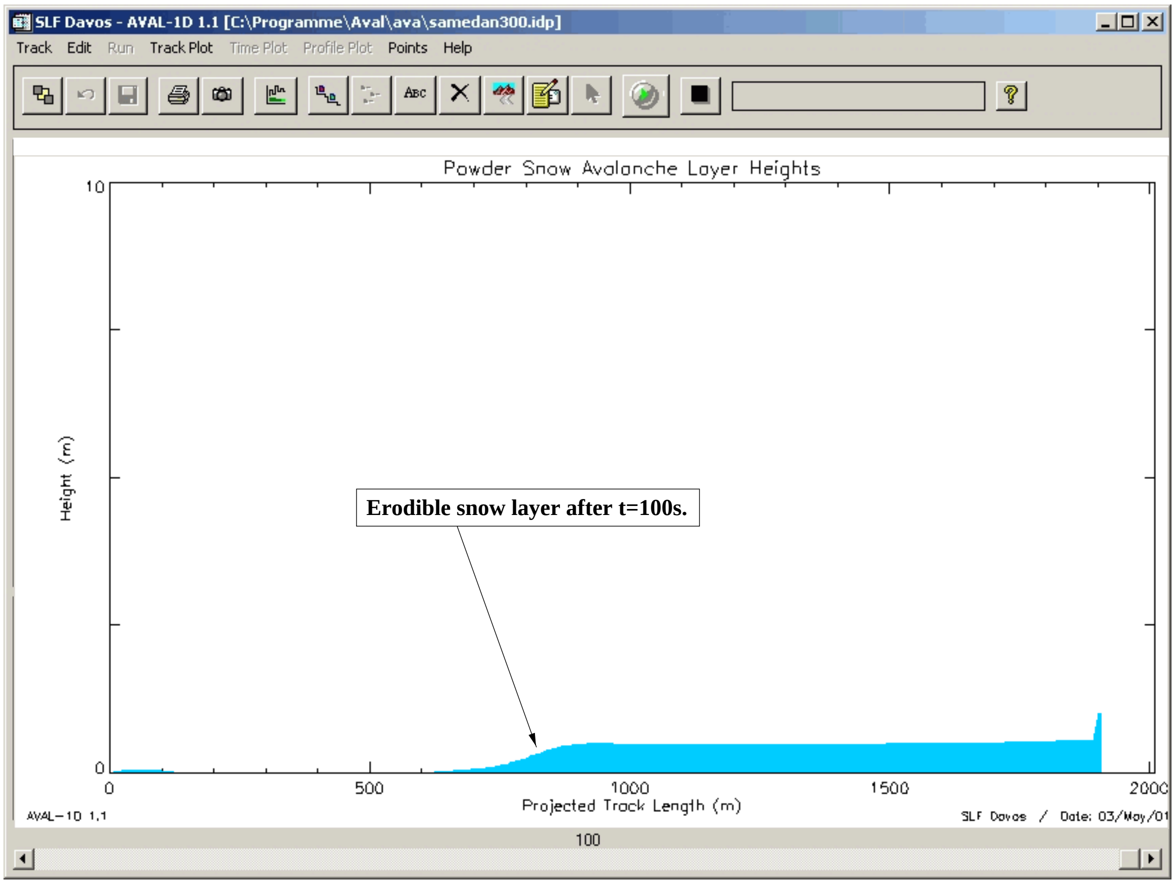


Figure 93: Erodible snow layer at the time t=100s, shown in the enlarged parameter window.

It should be noted that the second element was also given an erodible snow layer during the choice of parameters (see table 4, p. 101) and the erodible snow layer therefore decreases linearly to zero in the first element. It would be more realistic not to attribute an erodible snow layer to the second element (the result of this would be that the erodible layer would decrease to zero in the second, small element and that the first element would no longer have an erodible snow layer).

Animated display of the development of pressure, velocity and density: These results are all shown in the parameter window. When you click on **Track Plot** → **Pressure** or → **Velocity** or → **Density** you are asked which heights are of interest to you.

Exercise 11
The development of velocity at 2, 10 and 20m height is to be investigated. Select **Track Plot** → **Velocity** and enter the three heights (in the dialogue window **Selection of Height Above Ground**, see figure 52, p. 66). Using **Add**, the entered heights are transferred to the parameter window, and **OK** when you have finished entering the heights. Your display should look like figure 94. You can move the time step bar using the mouse and thus observe the velocity values at each point in time (or click on the **Animation**-button to animate the display). The maximum value is not reached at the same time everywhere. You can therefore click the right mouse button in the parameter window and choose **Max Values** to display these values (see figure 95).

Time and profile plots of snow height, velocity, density and pressure for any given points: The time and profile plots are displayed in a separate window. Before one of these functions can be applied, points must be selected along the topography. For the sake of simplicity, we will use the same points as in the dense flow avalanche (2340, 2000, 1830 and 1710 m. a.s.l.).

Exercise 12
The development of velocity at 2, 10, and 20 m above the ground is to be displayed for the four control points (2340, 2000, 1830 and 1710 m. a.s.l.) in the time plot window and the verical maximum values in the profile plot window. For the timeplot, we will only use one height (1830 m. a.s.l.), to keep things simple (four points with three heights would produce 12 plots). Click on **Points** → **Select manually** and enter the altitude of the point. To obtain the time plot, select **Time Plot** → **Velocity** and enter the three altitudes - the evolution of velocity for this point at these heights is displayed, see figure 96. For the profile plot, enter all the four control points, **Points** → **Select manually**,and then select **Profile Plot** → **Velocity**, see figure 97.

The evolution of the layer heights can be observed with **Time Plot** → **Snow Height**. This does not require any additional height information. As the height of the suspension

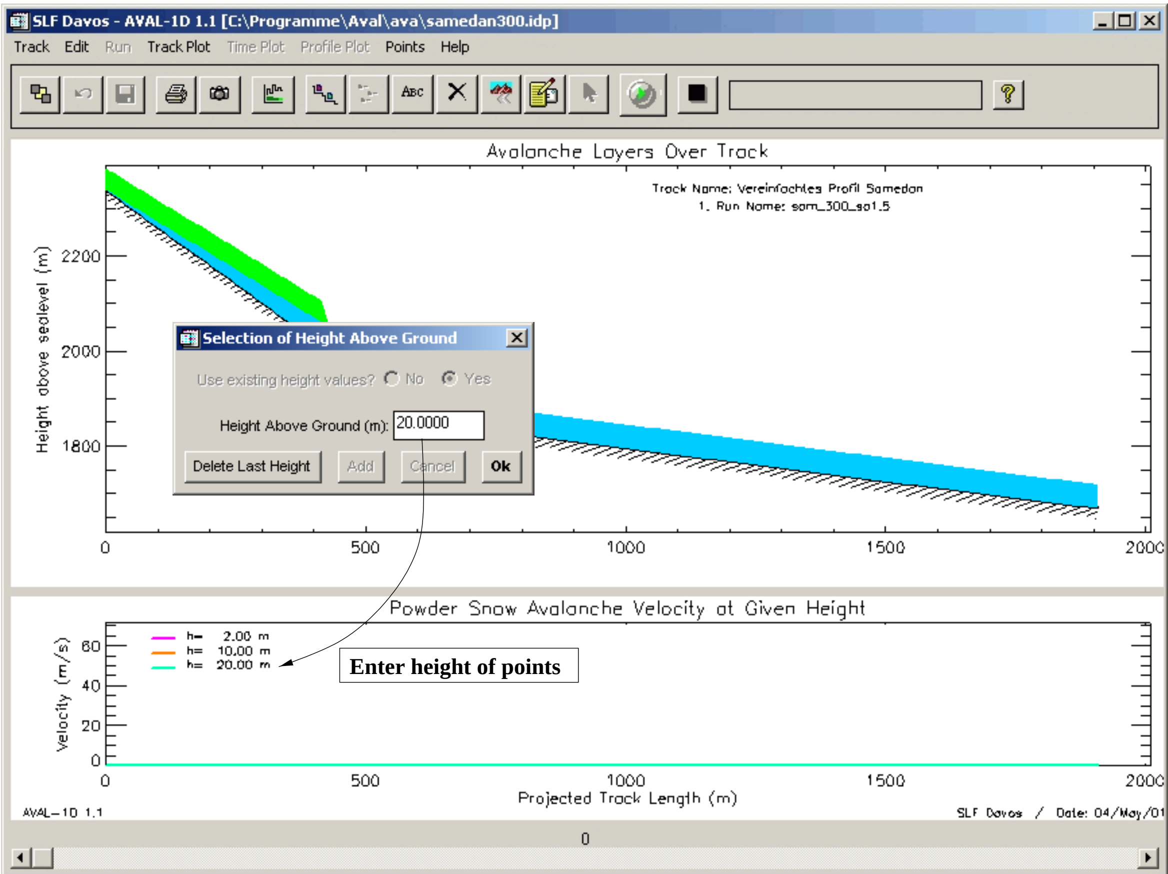


Figure 94: Display of the selected heights in the parameter window at time t=0 s.

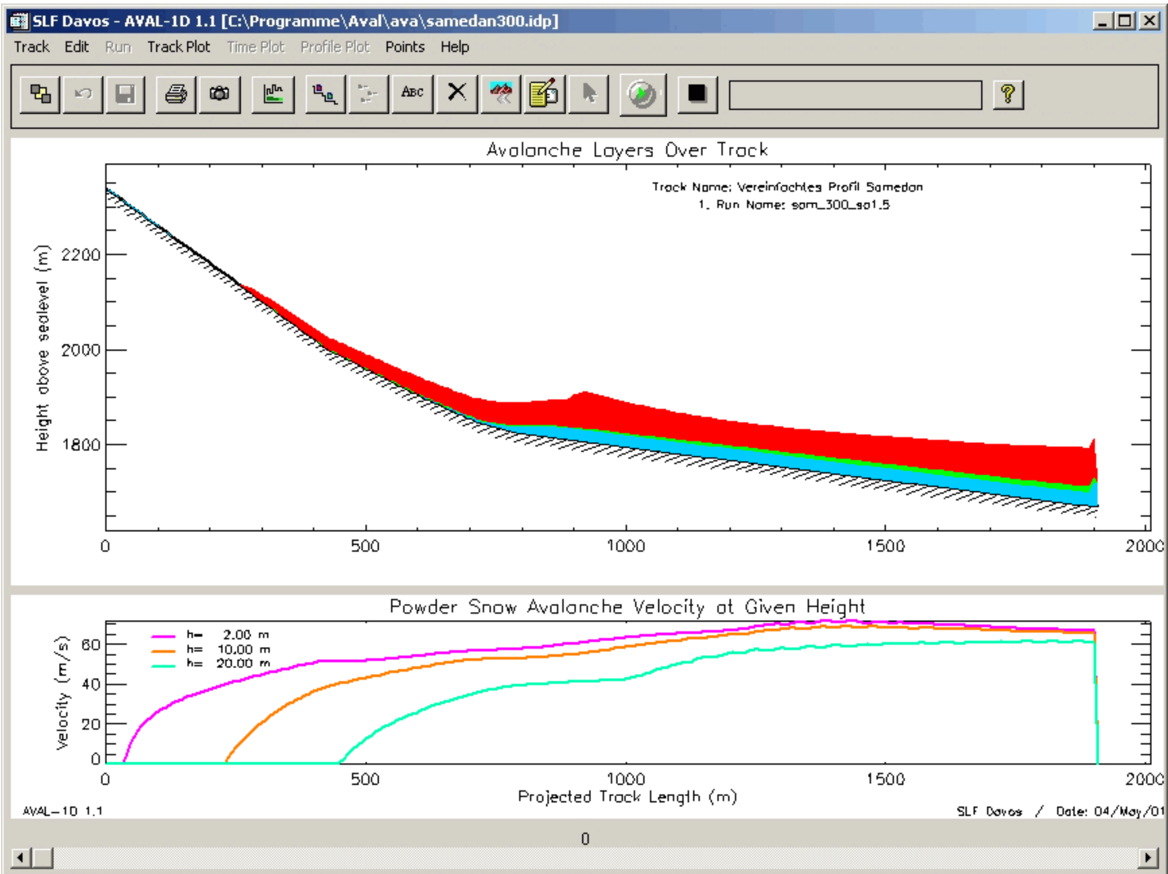


Figure 95: Maximum velocities (having clicked on **Max Values**), the time step bar is disabled.

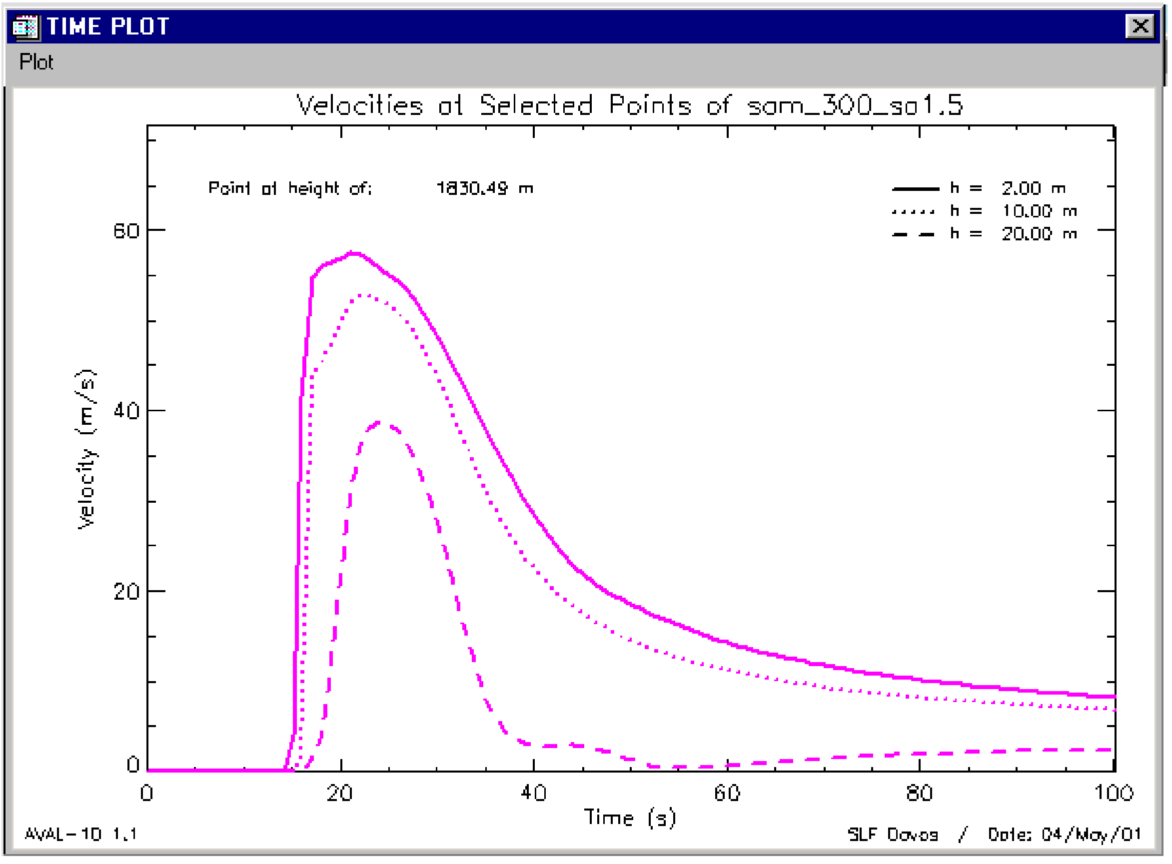


Figure 96: Evolution of velocity at 2.0, 10.0 and 20.0 m above the point 1830 m. a.s.l.

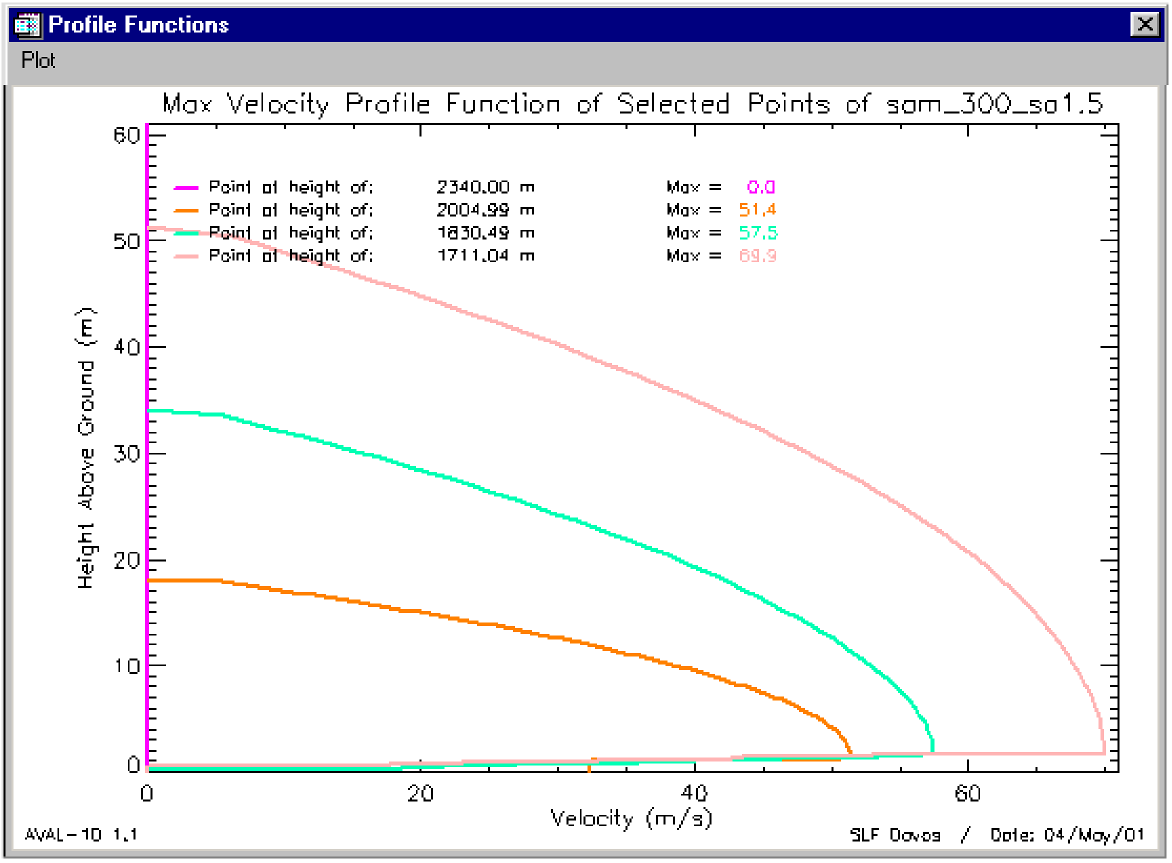


Figure 97: Profile plot of the velocities at points 2340, 2000, 1830 and 1710 m.a.s.l., - the maximum values reached during the simulation.

layer is usually much greater than the height of the saltation layer and the erodible snow layer, the y axis must be scaled with **Plot** → **Change Scaling**, in order to allow exact observation of the evolution of the latter two layers (see figure 98).

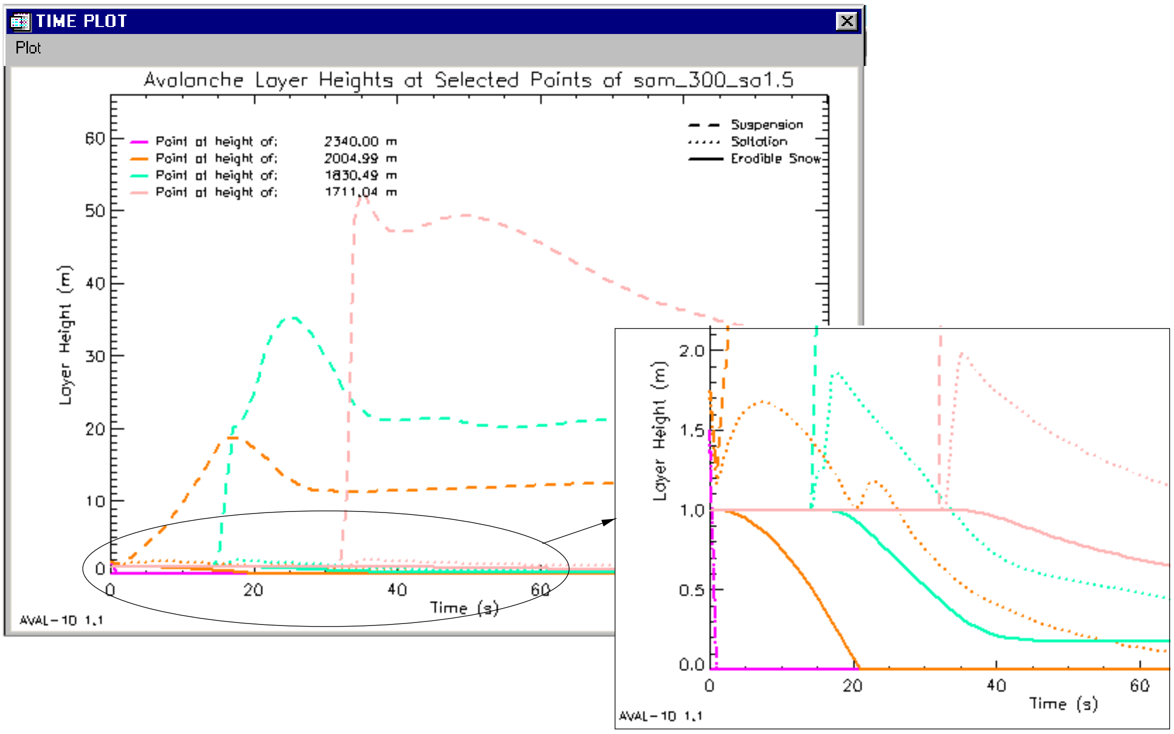


Figure 98: Development of the erodible snow layer, the saltation layer and the suspension layer at the point 1830 m. a.s.l.

Displaying the avalanche width in the topography window and the parameter window: The avalanche width can be displayed in both the topography window and in the parameter window. This is done with **Track Plot** → **Track Width On/Off** or with → **Track Width-Bottom**, see figure 99. The avalanche width is however not considered in the current version of `SL-1D 0.5.11`.

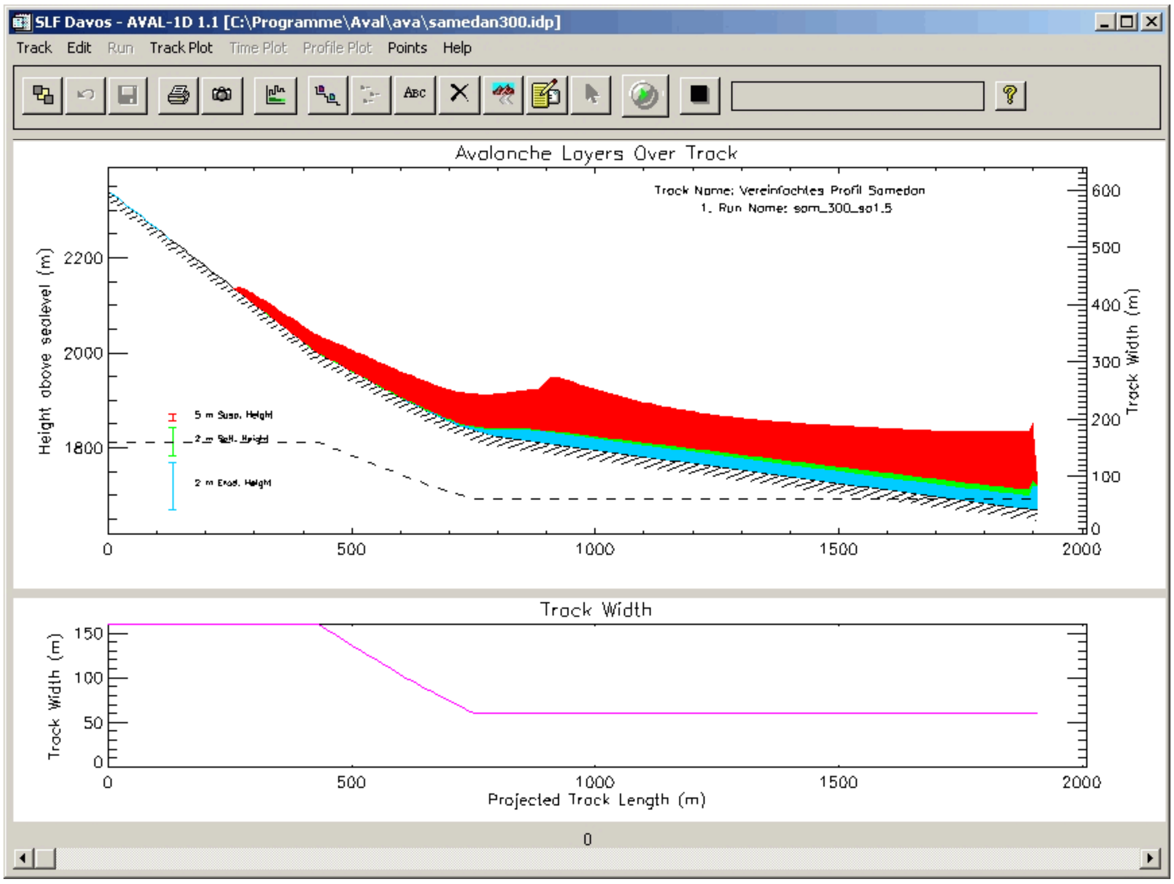


Figure 99: When the width of the avalanche track is shown in the parameter window, the time step bar is disabled.

A.8 How to export data and images.

Chapter 6.1 p. 71 contains information on how to print and export files. It is explained how the current display can be saved in a graphics file and how data can be exported as ASCII-files.

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