AVAL-1D: Calculation steps for dense flow avalanches

The most important steps calculating a dense flow avalanche:

1 Specify the topography

1.1 80 – 220m real distance rule

1.2 20m altitude-difference rule in the runout zone

1.3 Take sudden terrain changes into account

1.4 See Help menu for calculation of gullies (Help ➔ News ➔ Dense flow avalanche ➔ V-shaped cross section, more realistic flow heights for gullies!).

2 Specify the avalanche width

Take care that the avalanche width within the runout zone doesn't increase noticeably.

3 Determination of release depth d_0

3.1 Choose d_0^*

3.2 Altitude-correction ± 5cm / 100m (base: 2000m a.s.l.)

3.3 Determination of mean release zone slope angle

3.4 Slope angle correction f(φ)

4 Friction parameters m and x

4.1 Specify return period (30 or 300 years)

4.2 Choose track style (unchannelled, channelled or gully)

4.3 Choose µ and ξ (see table on the back...); **IMPORTANT**: AVAL-1D provides a proposal for µ and ξ. Click **Use SLF proposal** to accept this proposal, see dialogue window on the back.

5 Specify calculation parameters

Normally these parameters do not have to be changed.

6 Calculation and plausibility check of simulation results

Choose a new name for each calculation. AVAL-1D saves automatically an input file with the same name.

6.1 Are the simulation results realistic?

6.2 Do sensitivity studies.

1 Specify the topography

Rules for specifying a topography:

1. The 'real' distance between two topography points should be between 80 and 220m.
2. Runout zone: The difference in altitude between two topography points should not be less than 20m, as long as rule 1 is not broken (10m altitude difference only if slope angle less than 5°!) .
3. In case of a sudden change from acceleration zone to horizontal runout zone (0°) smaller distances can be specified in order to more accurately model the real topography.
4. Taking into consideration rules 1-3, try to accurately model the characteristics of the real topography.

Using rules 1-4 the topography will be slightly smoothed.This smoothness is necessary because snow will fill unevenness in the topography and - especially with large avalanches - because small bumps will have no big influence on an avalanche. The FL-1D model is very sensitive to slight changes in the slope angle. Many changes in slope angle will slow down the avalanche more than with a mean slope angle. This is the reason why minimum distances have been introduced.

2 Specify the avalanche width

The avalanche width has to be guessed from cadastre information and field visits. Furthermore, take care that the avalanche width within the runout zone doesn't increase noticeably, even if the observed avalanche did. This conservative rule increases the runout length and thus the security. The analytical Voellmy-Salm-model uses the same principle; the width B_P at Point P is decisive for the runout length.

3 Determination of release depth d_0

The release area is given by a slope angle area between 30° (28°) and 50°. The mean release depth d_0 perpendicular to the slope is calculated from:

$$d_0 = d_0^* \cdot f(?)$$

where:

•d_0^*: Base value, influenced by climatic conditions (possible new snow height within 3 days) and return period T. These values are valid for altitudes of 2000 m.a.s.l. and slope angles of 28°. Increase or decrease this values by 5cm/100 m for higher (+) or lower (-) regions. If there are regions (within the release area) with wind drift then d_0^* has to be increased there by 0.3 to 0.5m. The final d_0^* is the mean value over the whole release area.

•$f(?)$: Slope angle factor, given by snow stability (increasing d_0^* with increasing stability), see table on the right.

4 Friction parameters m and x

The factor turbulent friction **?** depends mostly on the geometry of the acceleration zone (roughness, confinement, trees). Large avalanches can smooth moderate roughnesses. Therefore use the maximum value of **?**, if you're not sure.
The friction coefficient **µ** depends on the snow characteristics (temperature, density, water content), but also on the avalanche pressure perpendicular to the ground and on the velocity (decrease with increasing velocity).

4.1 Specify return period (30 or 300 years)

Contrary to the analytical Voellmy-Salm model, the friction parameters of the FL-1D model are varied due to the return period. The reason for this change is that for a return period of 30-years not only a smaller fracture depth should be applied but also different snow conditions.

Table: Slope angle factors f (?)

ψ (°):	f(ψ):	ψ(°):	f(ψ):
28	**1.0**	39	**0.62**
28.5	**0.97**	39.5	**0.61**
29	**0.94**	40	**0.60**
29.5	**0.92**	40.5	**0.59**
30	**0.90**	41	**0.58**
30.5	**0.87**	41.5	**0.57**
31	**0.85**	42	**0.56**
31.5	**0.83**	42.5	**0.55**
32	**0.81**	43	**0.54**
32.5	**0.79**	43.5	**0.54**
33	**0.78**	44	**0.53**
33.5	**0.76**	44.5	**0.52**
34	**0.74**	45	**0.52**
34.5	**0.73**	45.5	**0.51**
35	**0.71**	46	**0.50**
35.5	**0.70**	46.5	**0.50**
36	**0.69**	47	**0.49**
36.5	**0.67**	47.5	**0.48**
37	**0.66**	48	**0.48**
37.5	**0.65**	48.5	**0.47**
38	**0.64**	49	**0.47**
38.5	**0.63**	49.5	**0.46**
39	**0.62**	50	**0.46**

4.2 Choose track style (unchannelled, channelled or gully)

Category	Definition
unchannelled	Curvature of contour line > 90
channelled	Curvature of contour line < 90 & Flow width/Flow depth > 3/1
gully	Curvature of contour line < 60 & Flow width/Flow depth < 3/1, very high roughness (Order of magnitude [m])

See Help menu for calculation of gullies (Help ➔ News ➔ Dense flow avalanche ➔ V-shaped cross section, more realistic flow heights for gullies!).

4.3 Choose m and x

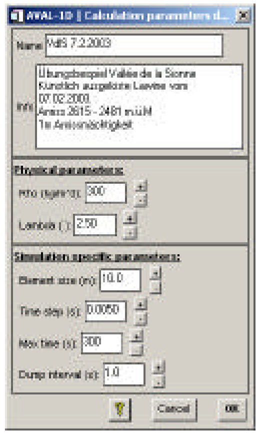
Large avalanche (> 60'000 m³)		300-Year		30-Year	
	Altitude (m.a.s.l.)	μ	ξ	μ	ξ
unchannelled	above 1500	0.16	2500	0.17	2000
	1000 - 1500	0.18	2000	0.19	1750
	below 1000	0.20	1750	0.21	1500
channelled	above 1500	0.20	1750	0.21	1500
	1000 - 1500	0.25	1500	0.26	1500
	below 1000	0.30	1200	0.31	1200
gully	above 1500	0.30	1000	0.31	800
	1000 - 1500	0.34	750	0.35	600
	below 1000	0.38	500	0.39	400
Mean size avalanche (25'000 - 60'000 m³)					
unchannelled	above 1500	0.20	2000	0.21	1750
	1000 - 1500	0.24	1500	0.25	1500
	below 1000	0.28	1200	0.29	1200
channelled	above 1500	0.26	1200	0.27	1200
	1000 - 1500	0.29	1200	0.31	1200
	below 1000	0.33	1000	0.34	1000
gully	above 1500	0.33	1000	0.34	800
	1000 - 1500	0.37	800	0.38	600
	below 1000	0.40	500	0.41	400
Small avalanche & wet snow avalanche (< 25'000 m³)					
unchannelled	above 1500	0.30	1500	0.31	1200
	1000 - 1500	0.32	1200	0.33	1200
	below 1000	0.34	1200	0.35	1000
channelled	above 1500	0.32	1200	0.33	1000
	1000 - 1500	0.34	1000	0.35	800
	below 1000	0.36	800	0.37	600
gully	above 1500	0.36	800	0.37	600
	1000 - 1500	0.40	500	0.41	400
	below 1000	0.42	500	0.43	400

IMPORTANT : AVAL-1D provides a proposal for μ and ξ . Click **Use SLF proposal** to accept this proposal, see dialogue window on the right.

IMPORTANT : AVAL-1D uses **ALWAYS** the white line for the calculation! The red line is only indicating the proposal.

5 The calculation parameters

Element size (10m), time step (0.005s), max time (300s) and dump interval (1s). Normally these parameters do not have to be changed (default values). They have to be adapted if numerical instabilities occur or if the avalanche doesn't reach the runout after 300s, see Help ➔ FAQ. Rho (300kg/m^3) and Lambda (2.5) shouldn't be changed normally.



Choose: *Edit* ➔ *Calculation parameters...* ➔ *Dense flow*

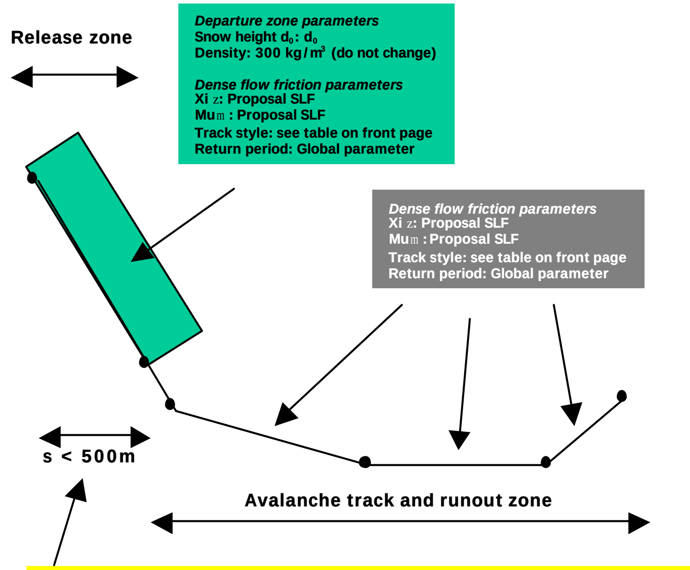
or Toolbar ➔

Specify additional monitoring points (Monitoring Points)

It is recommended to specify additional monitoring points along the profile to better document the simulation. The max velocity and flow height values for these monitoring points will be written into the LOG-file. Besides the distances between the monitoring points and the end of red and blue pressure zones are calculated and added to the LOG-file. It is not mandatory to enter monitoring points and it has no influence on the simulation results. (***Edit* ➔ *Edit topography*, *M. Point?***).

6 Calculation and plausibility check of simulation results

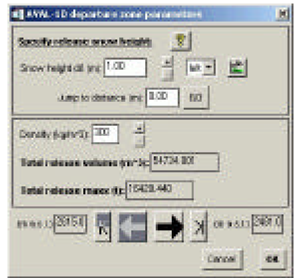
It is very important to check the plausibility of the simulation results. Compare the results with the available cadastre information. To evaluate the quality of the results it is recommended to do sensitivity studies.
Both the numerical and the analytical model are very sensitive to slight changes in the slope angle in the runout zone, especially if the slope angle is near tanψ = μ. A difference of 0.5° around these slope angles over longer distances can result in considerable differences in the runout distance.
The parameter μ is a simple utility to recognize such critical slope angles. For large avalanches do a sensitivity analysis with a μ–value that is 0.01 smaller than before. If the runout distance is changing considerably, you're dealing with a critical slope angle. Thereupon you should try to eliminate these uncertainties by choosing different profiles in the runout zone and using the standard μ values. In doing so always remember that the profile with the longest runout distance will be the proper profile. For critical slope angles it is also important to carefully choose the avalanche width.

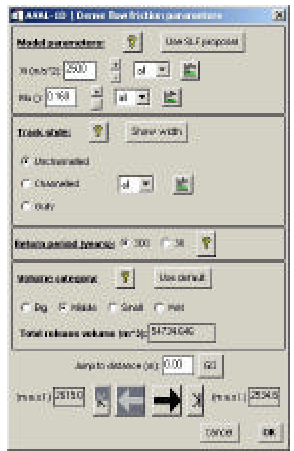


ATTENTION: The sum of all the horizontal lengths of the release areas must be less than 500m!!

Choose: *Edit* ➔ *Avalanche parameters...* ➔ *Dense flow – release zone*

or Toolbar ➔





Choose: *Edit* ➔ *Avalanche parameters...* ➔ *Dense flow – x i/mu*

or Toolbar ➔