RAMMS::Rockfall 1.8.26

New features of version 1.8.26

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August 2024

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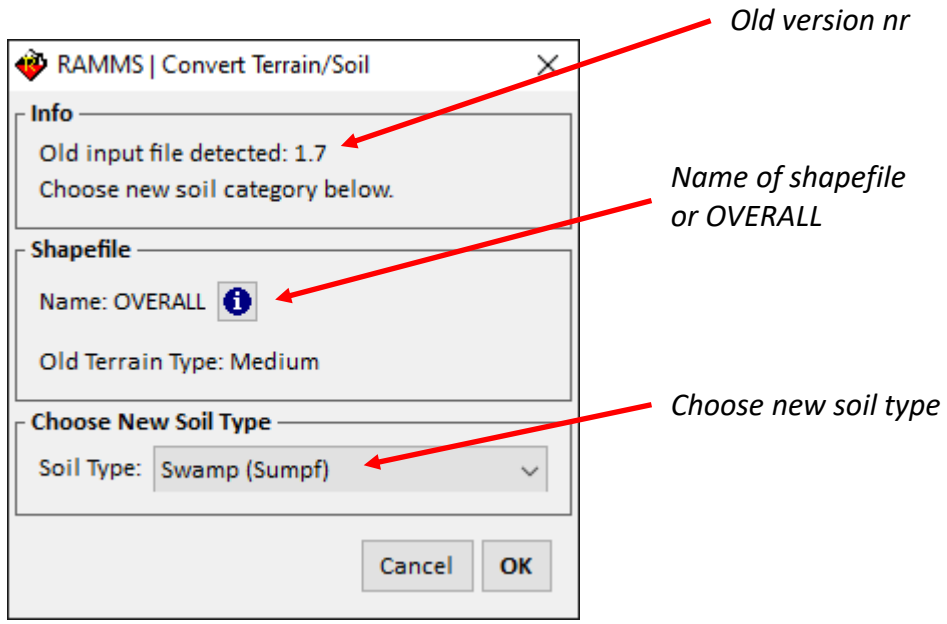
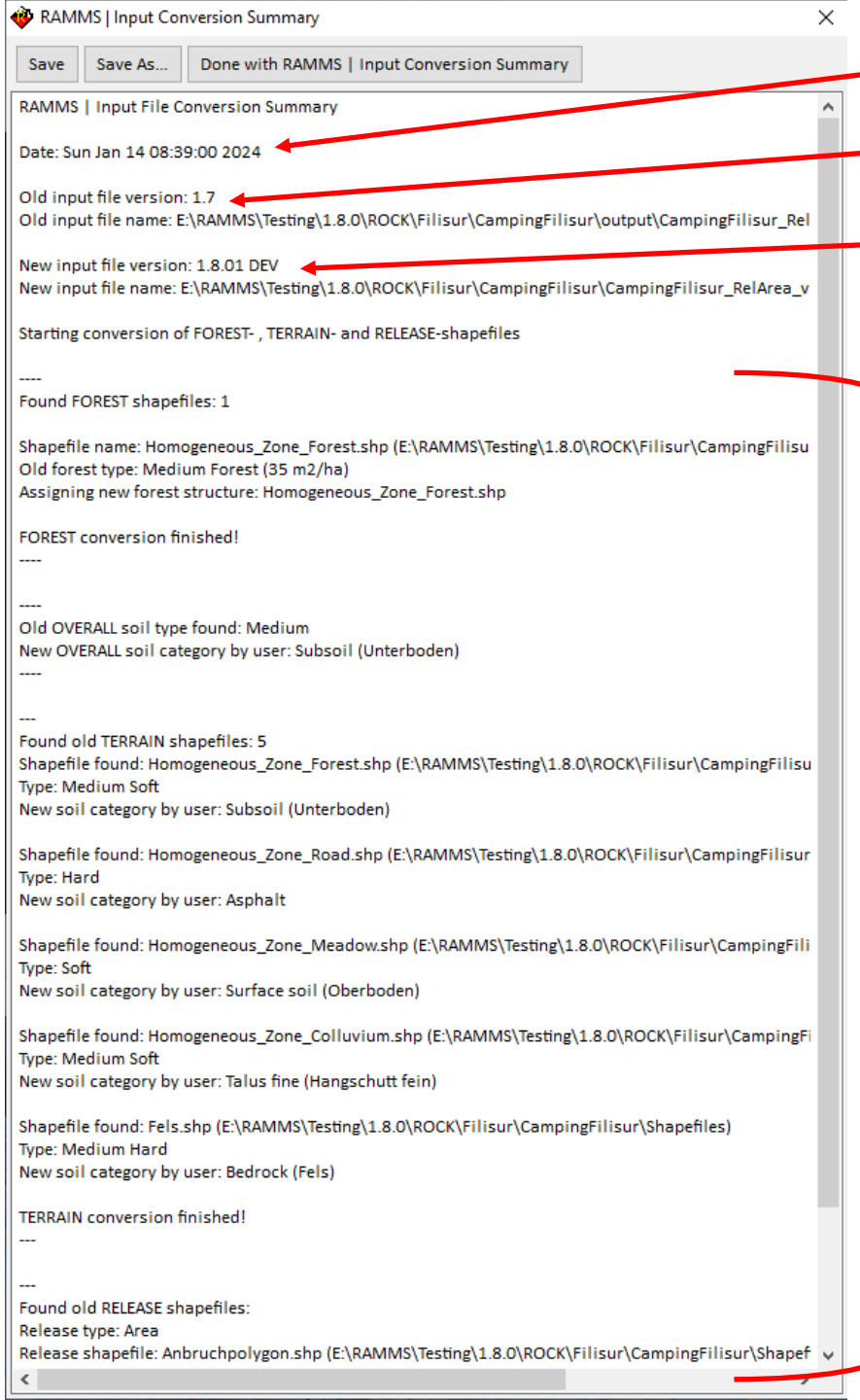
Open old projects

- RAMMS will detect «old» projects
- FOREST and RELEASE parameters are converted automatically
- For every TERRAIN-shapefile (and OVERALL terrain) you are asked to assign a new SOIL category
- If you click «cancel», NO soil category is assigned to the shapefile



Open old projects

- At the end of the conversion, a «conversion summary» is shown
- A new input file is saved in the *project* directory (not in the «old» scenario directory)



Date of conversion

Old version nr and file-path

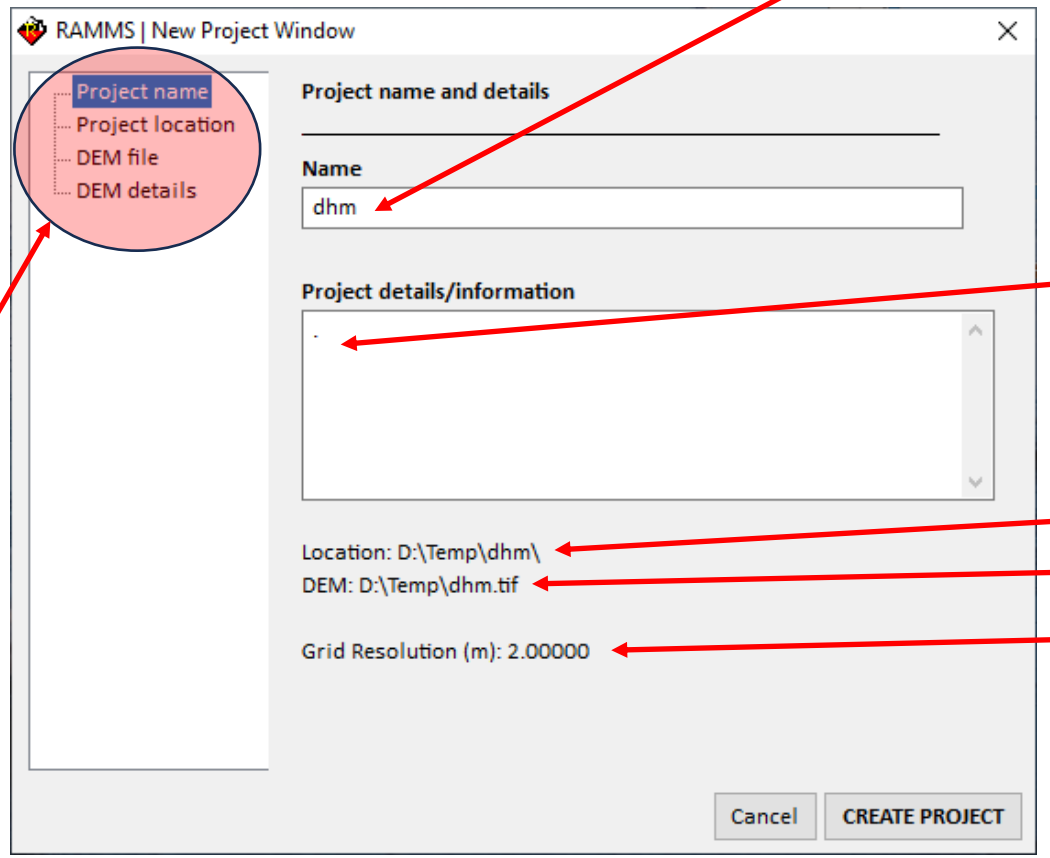
New version nr and file-path

Conversion summary

Create new project

New approach to create a new project

- Select DEM-file first
- Project-location and -name from DEM-location and –name



Project name suggestion

Enter project details

Project location

DEM file

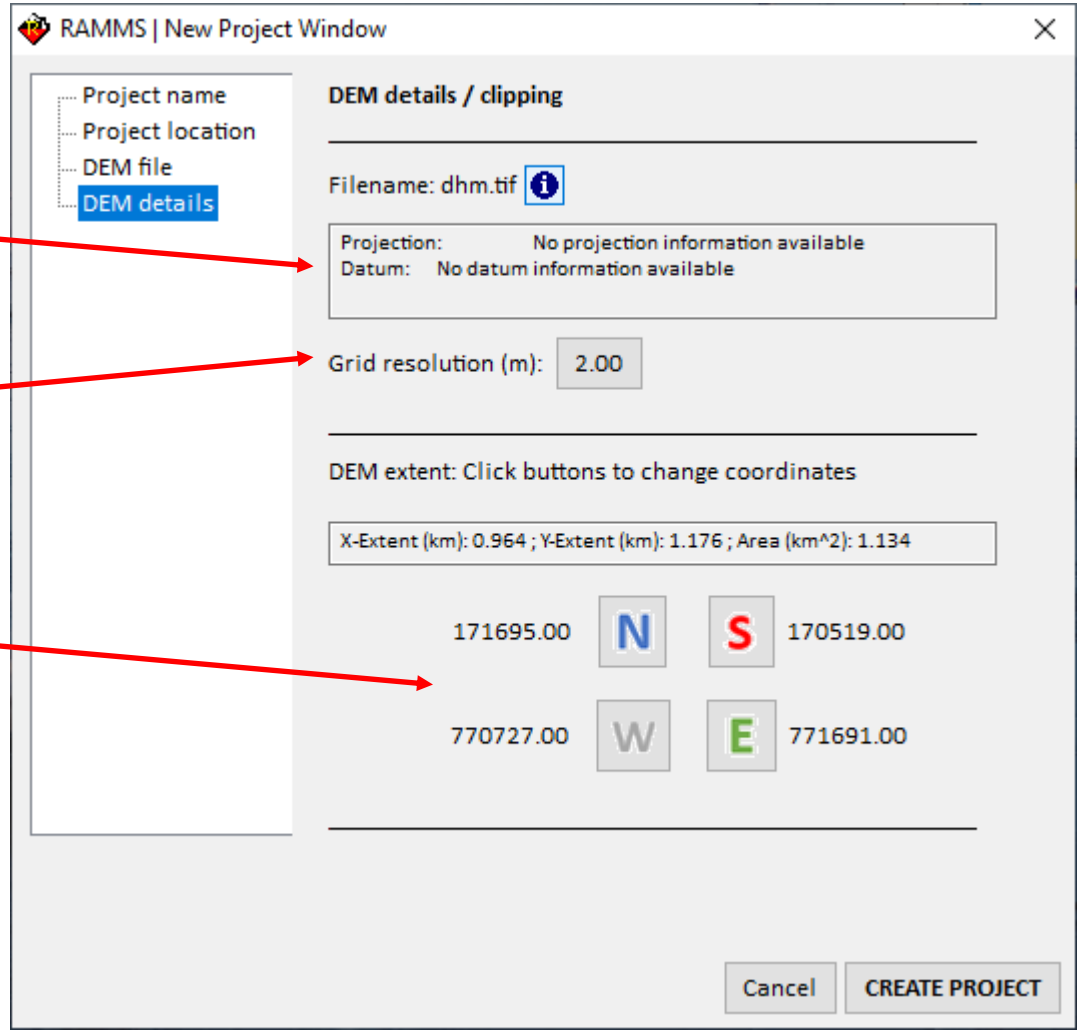
DEM grid resolution

Click to change project location or DEM file.
DEM details, see next slide

Create new project

DEM details:

- Projection info
- Change grid resolution
- Change DEM extent

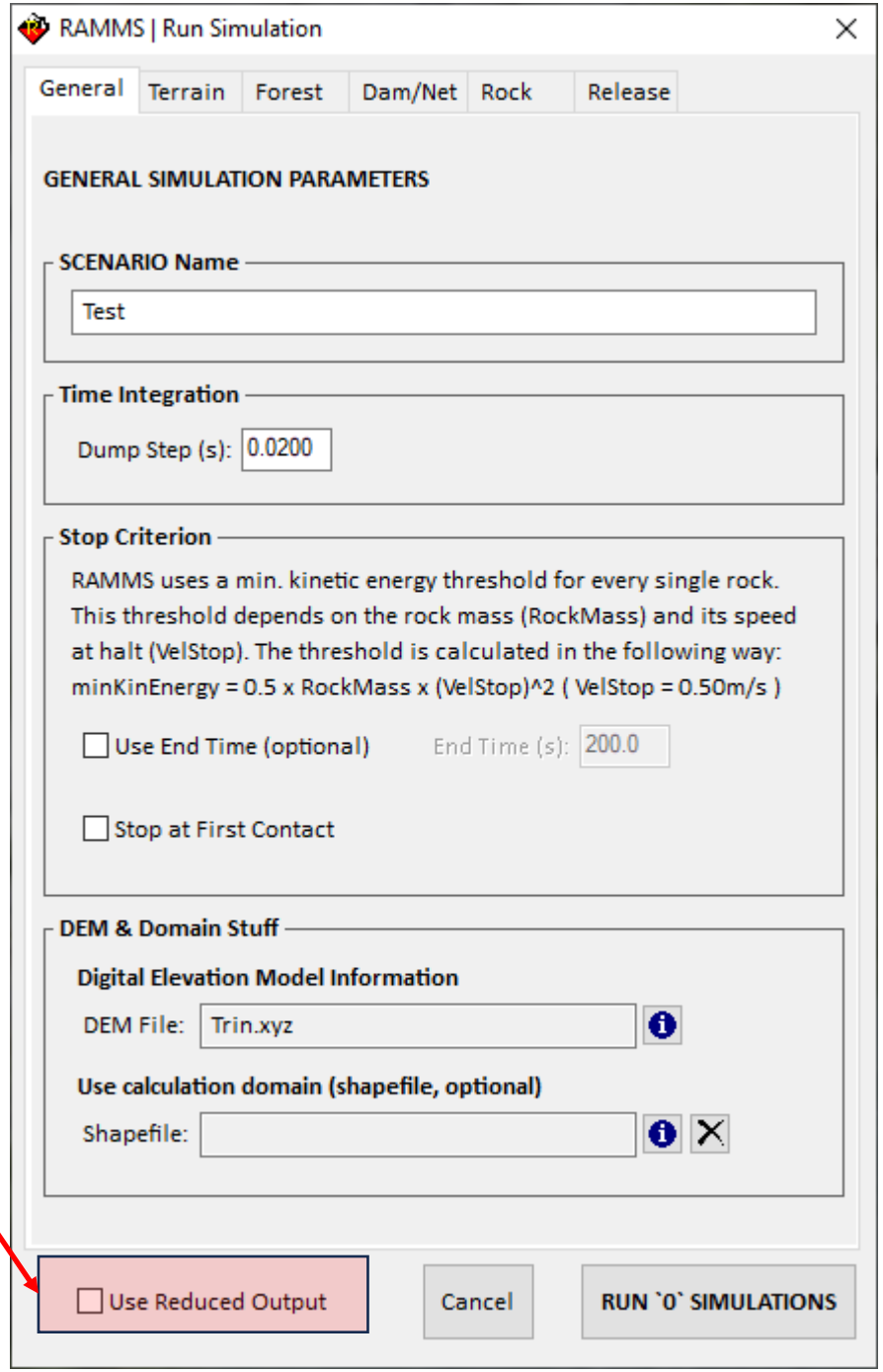


Reduced Output Files

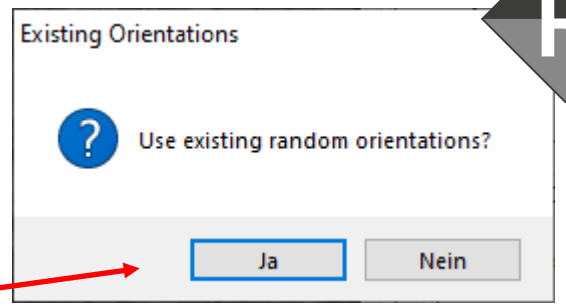
- Check this checkbox to use the «reduced output mode»
- If checked, the following output parameters are saved:

  - Kin. Energy
  - Jump Height
  - Velocity
  - Scar Depth

- This feature will speed up the simulations, and also save disk space.

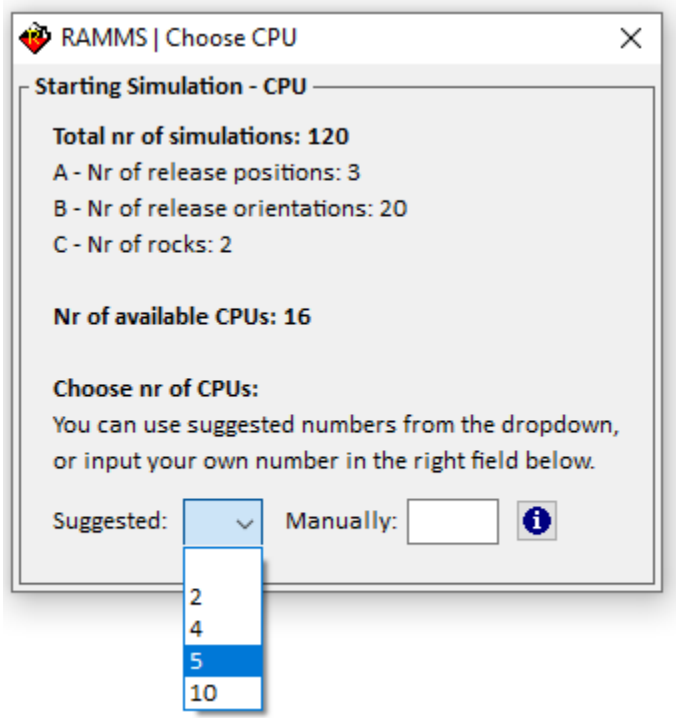


Running a simulation



New features when running a new simulation:

- Random orientations are saved
  (file: *.random.sav* in scenario-directory)
- Can be used for other simulations
  (click *Yes* and choose *.random.sav*-file from another scenario)
- Information window about «suggested nr of CPU's» and scenario summary is shown.
- Choose nr of CPU's with care, because can not be changed after starting a simulation! If you choose a nr from the dropdown menu, the simulation will start automatically!
- All simulation files are saved in separate folders, e.g. all trajectories in „traj_files“



Forest – old forest approach

- Hard to calibrate
- Rocks are not stopping, just slowing down

From old manual

Forest drag is given by (Figure 3.9):

$$F_{df} = -C_f v_s \qquad C_f = \begin{cases} \theta_f & \text{if } Z \le Z_h \\ 0 & Z > Z_h \end{cases} \tag{3.10}$$

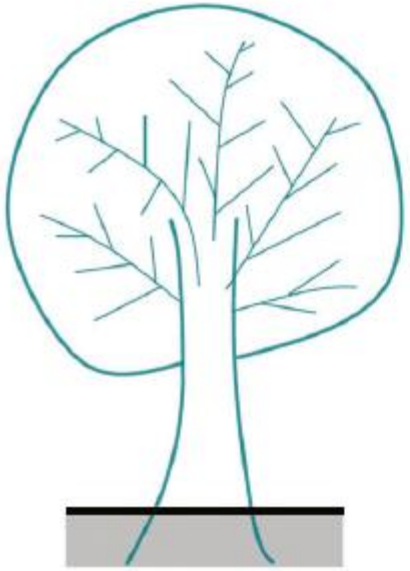
The idea behind forest drag is that a resisting force acts on the rock's center of mass when it is located below the drag layer height Z_h. This force is linearly proportional to the rock velocity v_s. The forest is parameterized by the effective height of the vegetation layer Z_h as well as the drag coefficient θ_f. The effective height Z_h roughly corresponds to the height of the forest but in some cases, for example old forests, the drag force in the tree crowns might be negligible and therefore the effective height could be smaller than the real tree height. The model does not account for a Z-dependency in forest structure as it assumes a homogeneous layer with mean drag properties. Typical values for Z_h are between 5 m and 30 m (default value is 30m); typical values for θ_f range between 100 kg/s and 1'000 kg/s. Three different forest types are implemented in RAMMS::ROCKFALL for now:

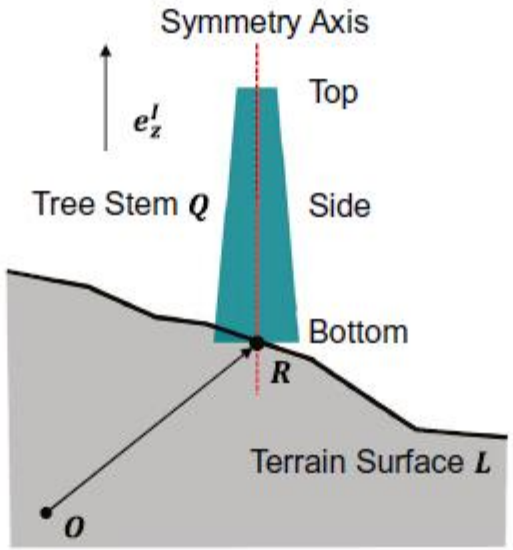
- Open Forest → 20 m^2/ha → forest drag = 250 kg/s
- Medium Forest → 35 m^2/ha → forest drag = 500 kg/s
- Dense Forest → 50 m^2/ha → forest drag = 750 kg/s

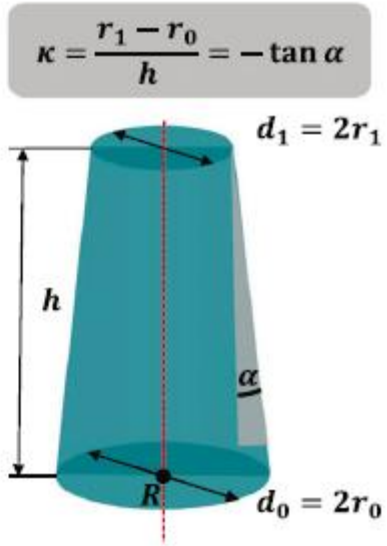
Figure 3.9: Forest drag F_{df} is implemented to act on the center of gravity of the rock-body at height Z.

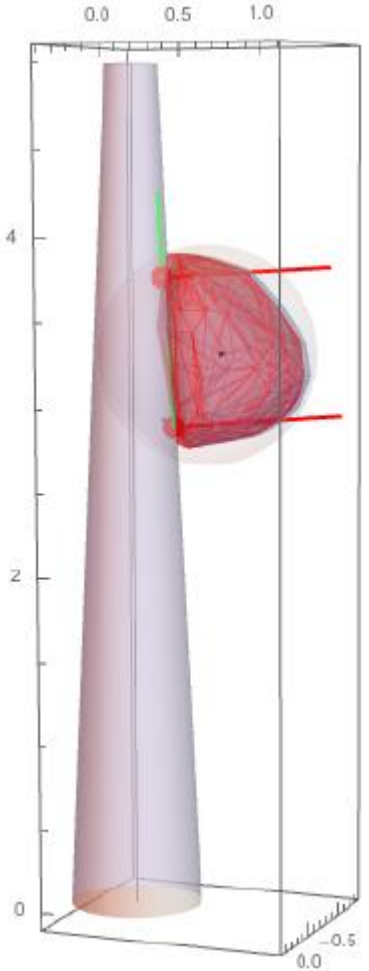
Forest – **NEW** forest approach

- Tree modelled as **truncated cone**, random distribution
- Rock-tree interaction is considered as hard contact
- Energy dissipation due to uprooting / swaying of tree stem/crown is not incorporated









Forest - Example

- Draw or import forest-shapefiles

- Forest types
  - Open Forest – 200 Trees/ha
  - Medium Forest – 400 Trees/ha
  - Dense Forest – 600 Trees/ha

- Assign forest for single polygons or whole shapefile

- Default forest visualization is to fill the shapefile with a pattern

Forest - Example

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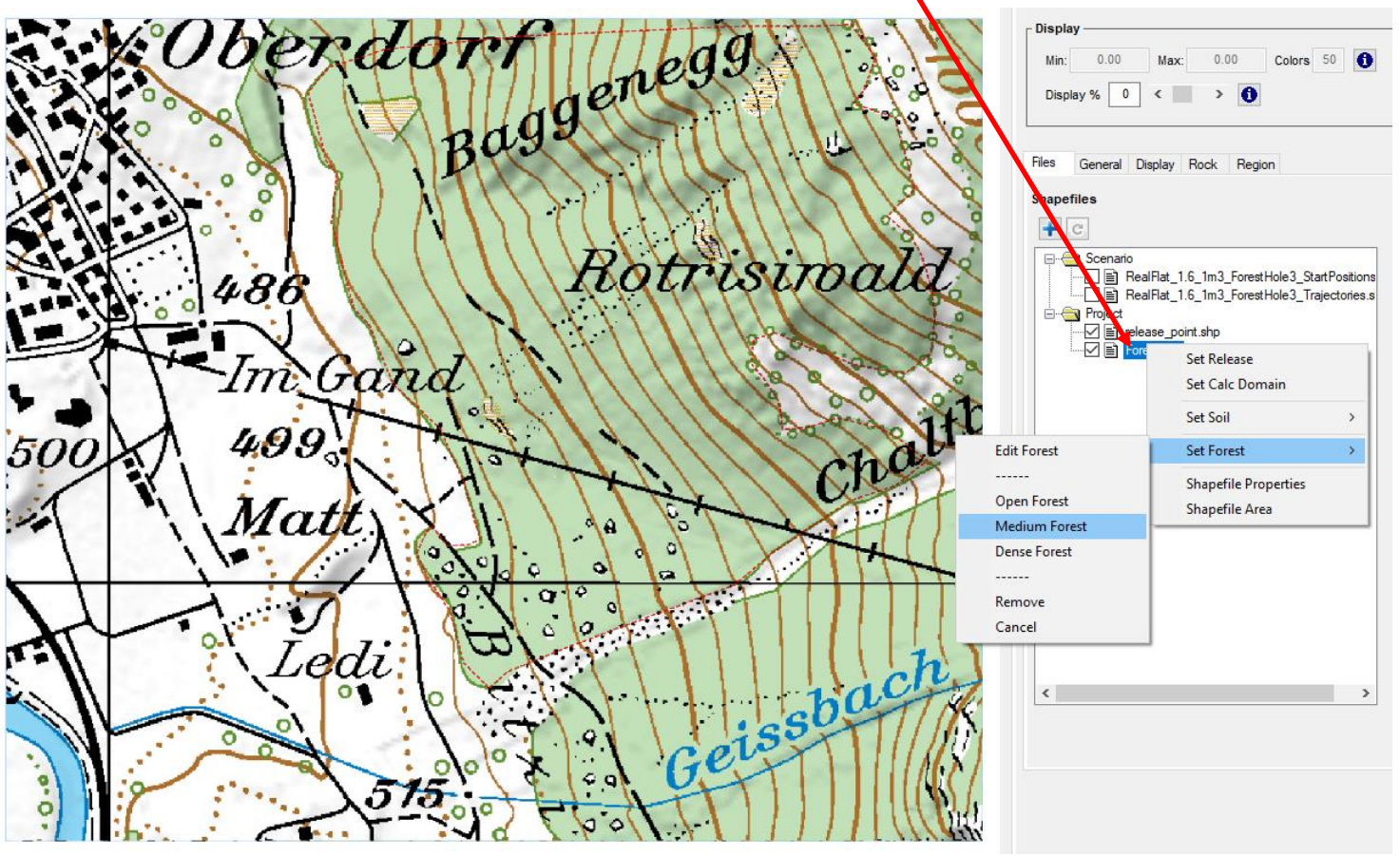
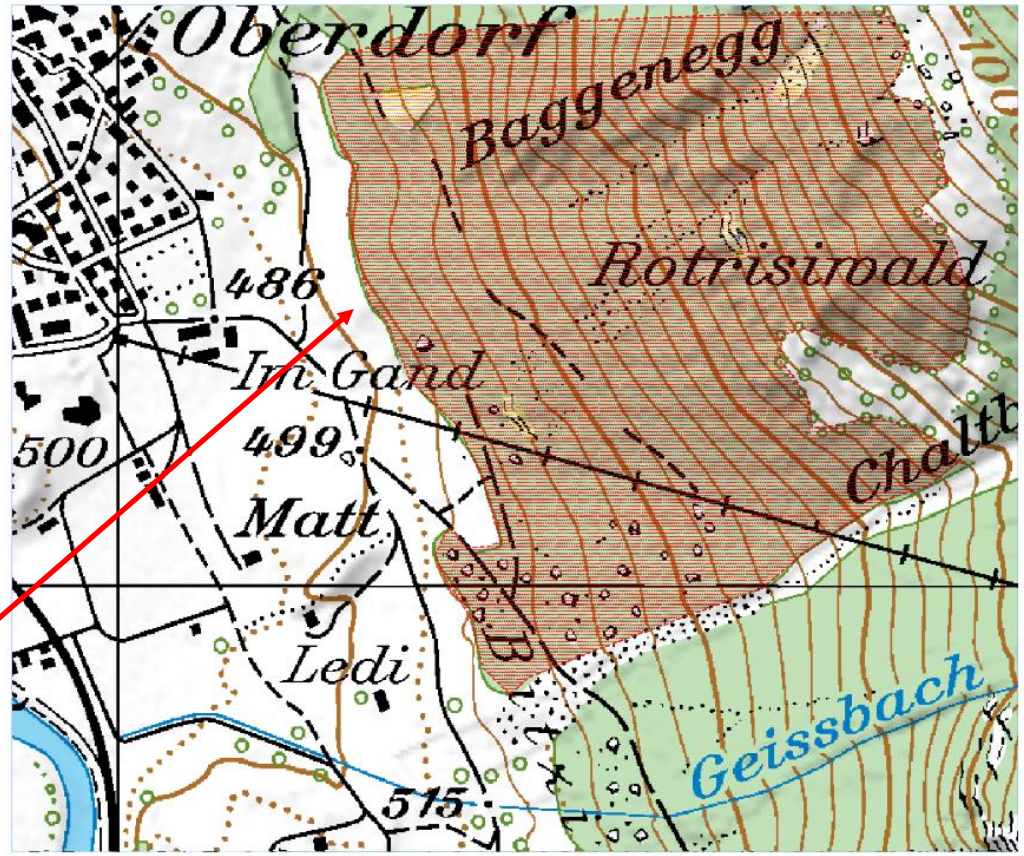
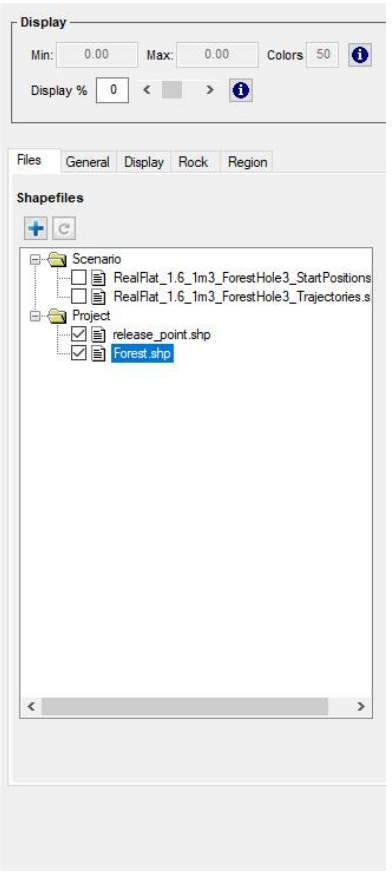


Forest - Example

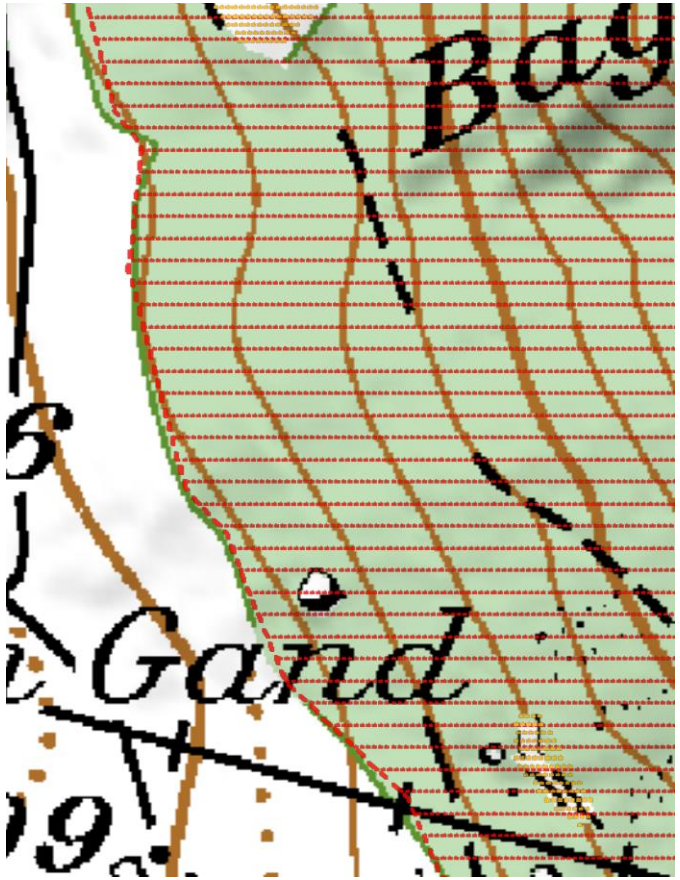
- Draw or import forest-shapefiles
- Forest types
  - Open Forest – 200 Trees/ha
  - Medium Forest – 400 Trees/ha
  - Dense Forest – 600 Trees/ha
- Assign forest for single polygons or whole shapefile
- Default forest visualization: fill the shapefile with a pattern (spacing of pattern lines depends on forest type)



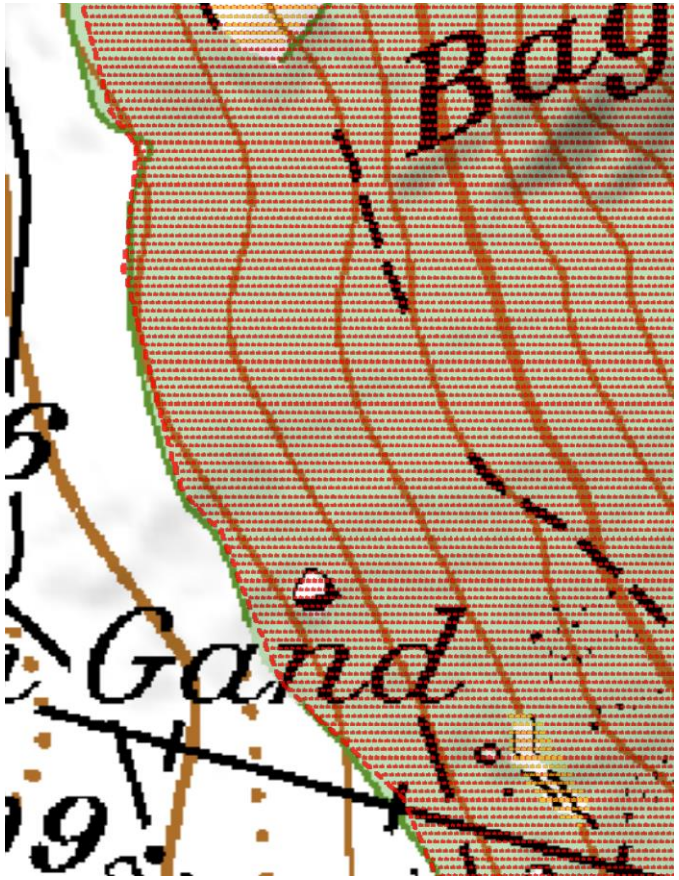


Forest - Example

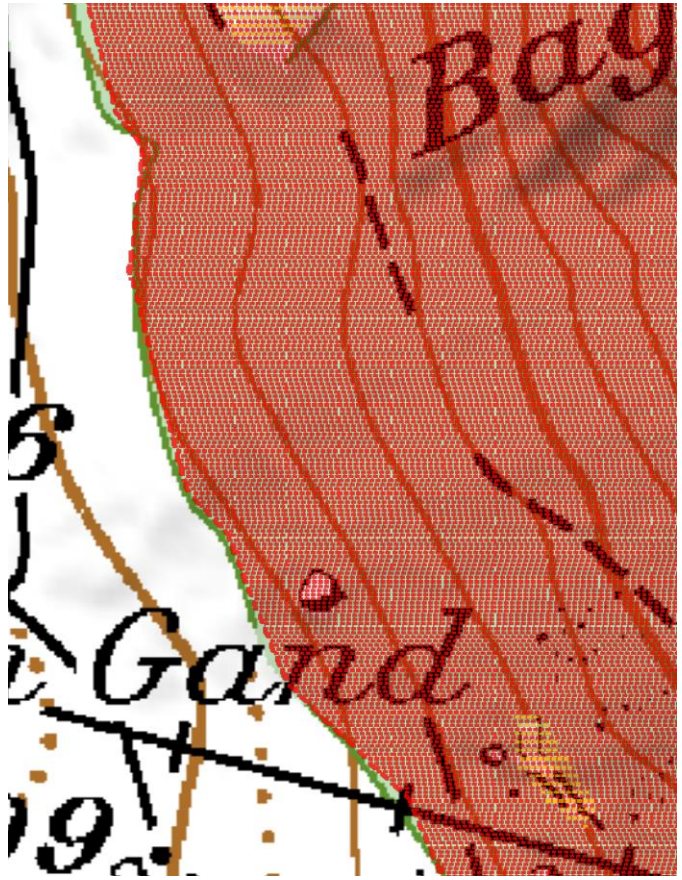
Open Forest



Medium Forest



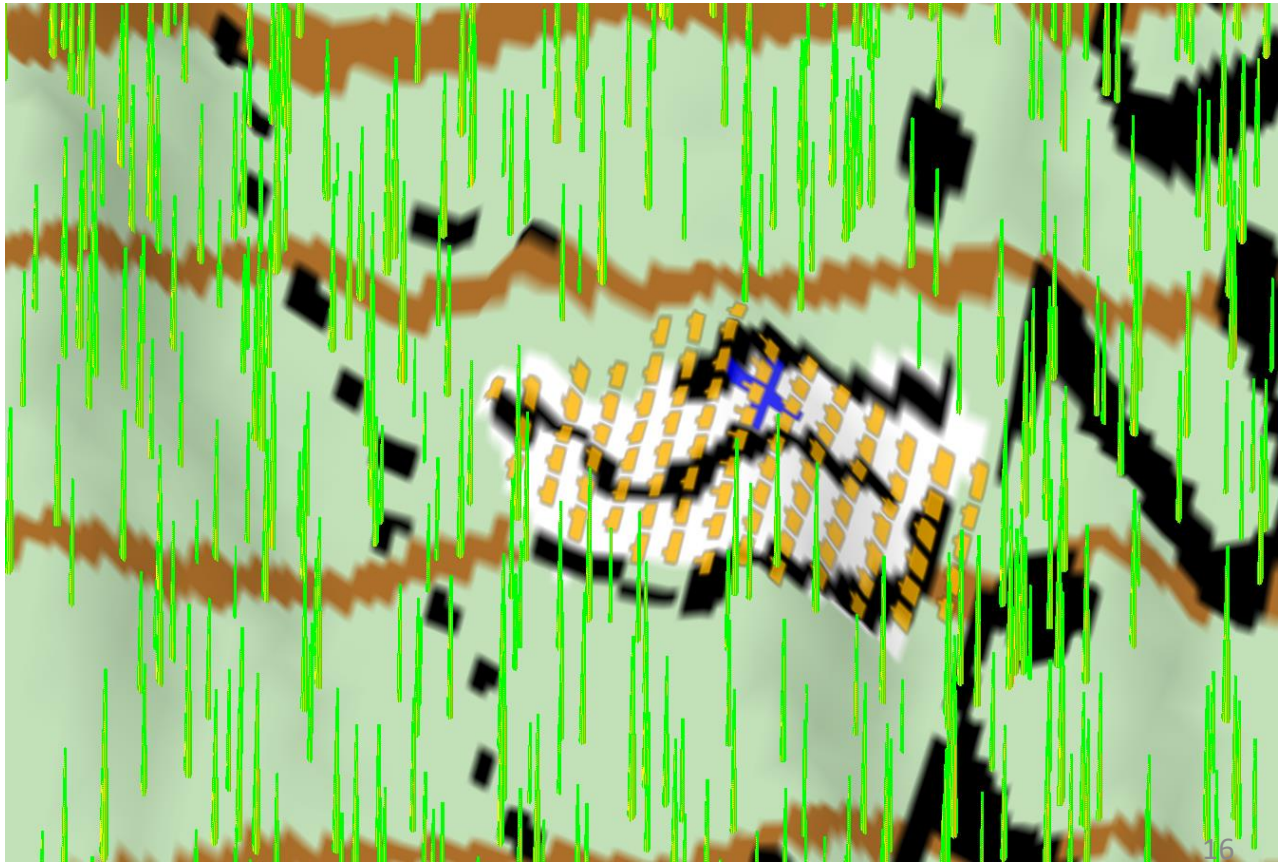
Dense Forest



Forest – Single Trees Visualization

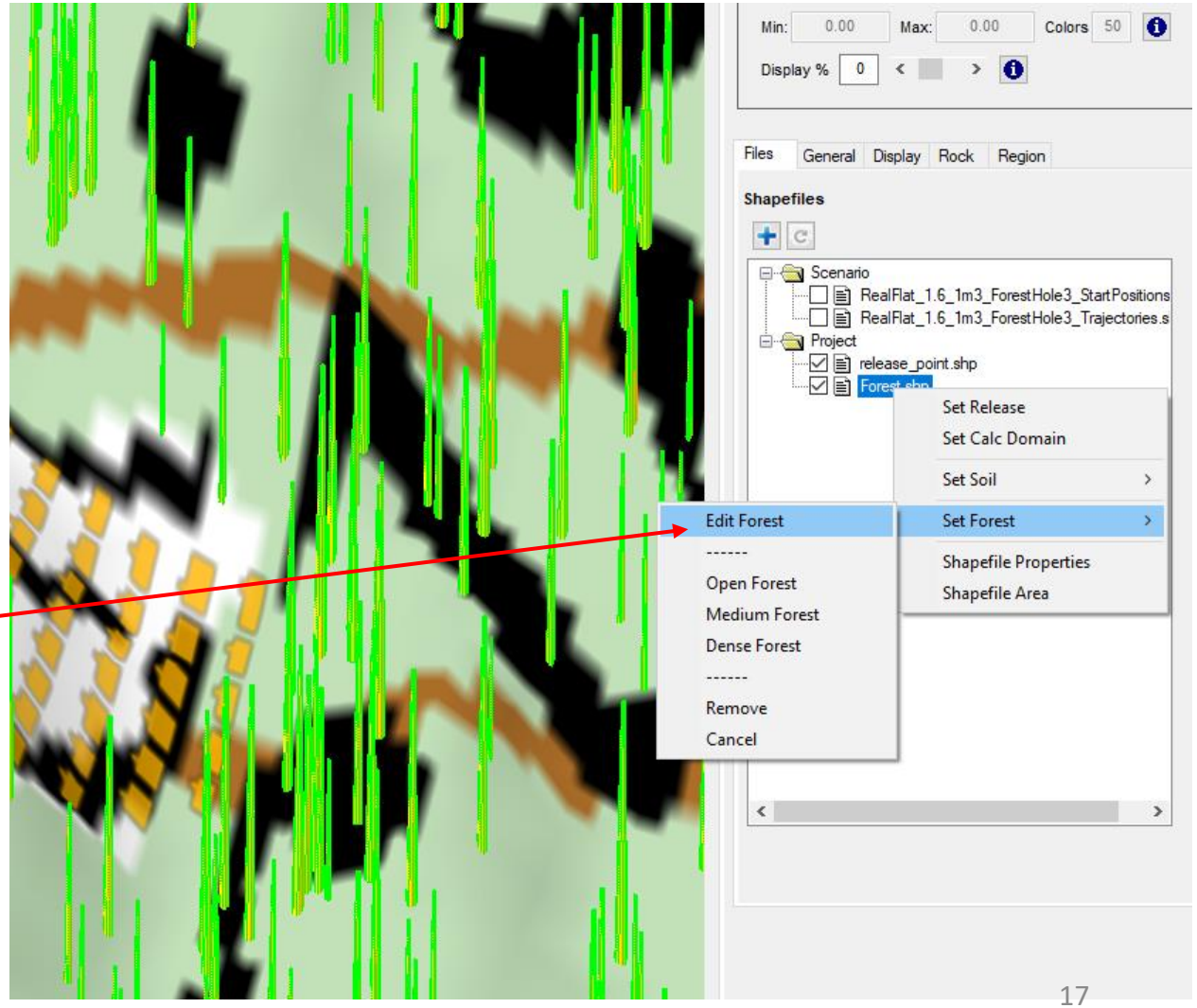
- It's possible to visualize the single trees: Menu ***"Show → Show Trees"***
  (this will take a while because the single tree objects have to be created! ~ 10s / 10'000 trees)

- In Output-Mode, only trees within
  a rectangular region around
  the trajectories are visualized!



Forest – Tree Distribution

- Trees are randomly distributed within a polygon region. Choose nr. of trees / ha.
- But what about tree diameters (DBH – diameter at breast height) and tree height?
  - Mean DBH and standard deviation can be set, and then a normal (Gaussian) distribution is calculated.
  - Edit a forest



Forest – Tree Distribution

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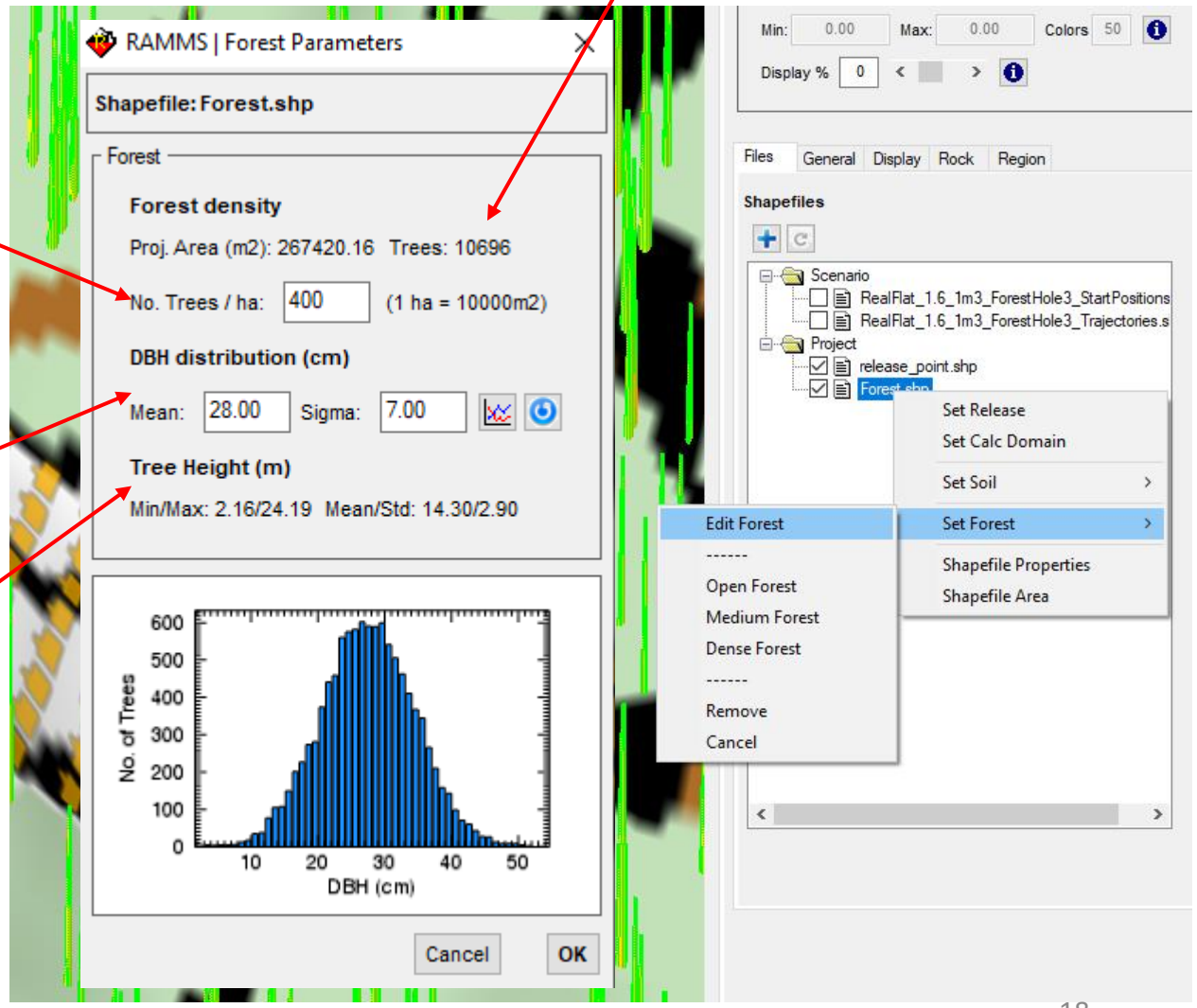
- But what about tree diameters (DBH – diameter at breast height) and tree height?
  - Mean DBH and standard deviation can be set, and then a normal (Gaussian) distribution is calculated.
  - Edit a forest
  - Tree height (m) = DBH (cm)$^{0.8}$ (empirical relation by L. Dorren)

Total nr of trees within forest polygon



Forest – Tree Destruction

- A kinetic energy threshold is automatically assigned to every tree

$$E_{diss\_max} = m \times 38.7 \times DBH\ (cm)^{2.31}\ (J) \qquad \text{(L. Dorren)}$$

The factor *m = 2* is used to take energy-loss during tree impacts and deflections into account

$Rock_{Ekin} < (0.5 \times E_{diss\_max})$ → Normal hit, rock is deflected, tree ~ok

$(0.5 \times E_{diss\_max}) < Rock_{Ekin} < E_{diss\_max}$ → Severe hit, rock is deflected, tree probably destroyed

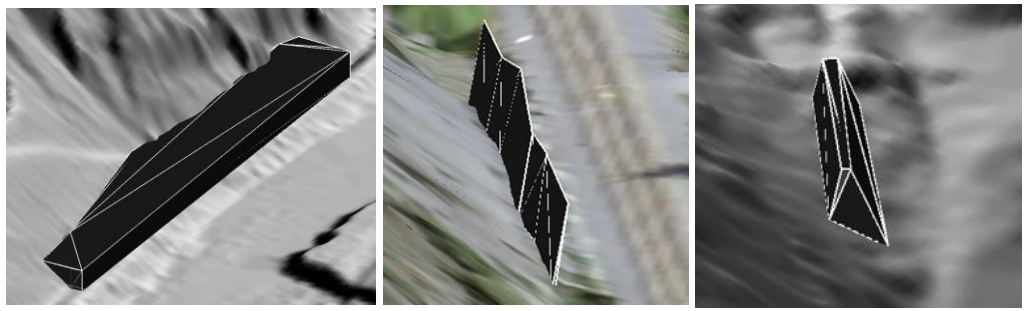
$Rock_{Ekin} > E_{diss\_max}$ → Kill hit, rock does NOT see tree, tree is killed

Artificial obstacles – Nets, Dams, Galleries

- Artificial obstacles are always defined as a point cloud and modeled as a convex hull (Point Cloud, Convex Hull).
- The maximum kinetic energy that an obstacle can absorb when the stone impacts is limited by an upper energy limit. For simplicity, it is assumed that an obstacle whose limit value is exceeded by the stone cannot have any influence on it. This means that collisions with these obstacles are registered during the simulation, but they have no influence on the stone trajectory.

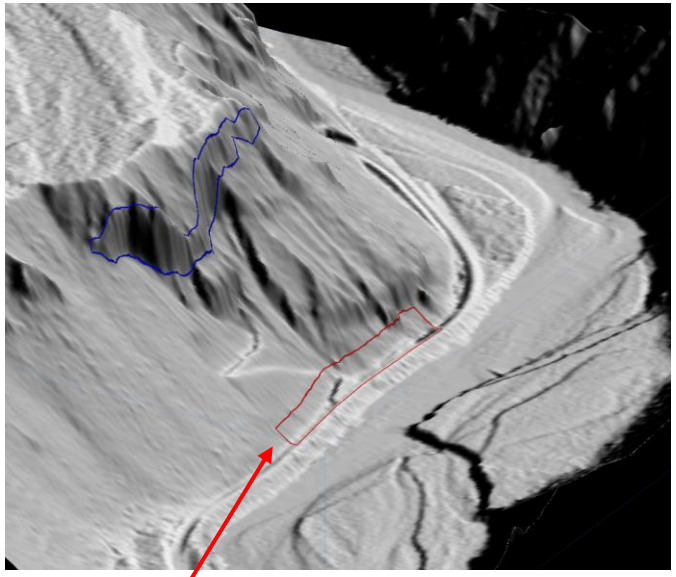
Examples of artificial obstacles:

- Galleries
- Rockfall net
- Dam



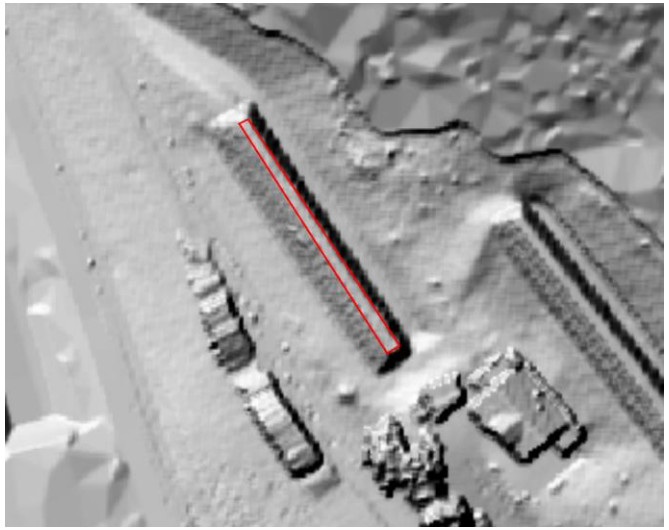
Galleries and Dams

- Draw one (1) outline shapefile for the gallery, or two (2) shapefiles for a dam (one shapefile for the dam foot, and one for the dam crest)

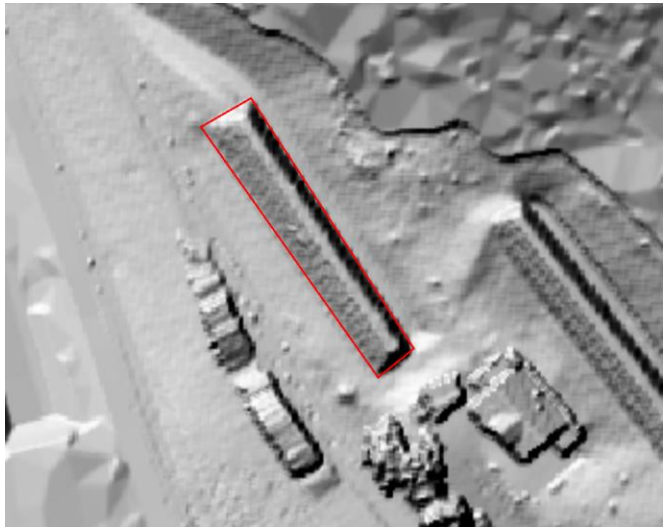


Gallery outline

Dam crest shapefile

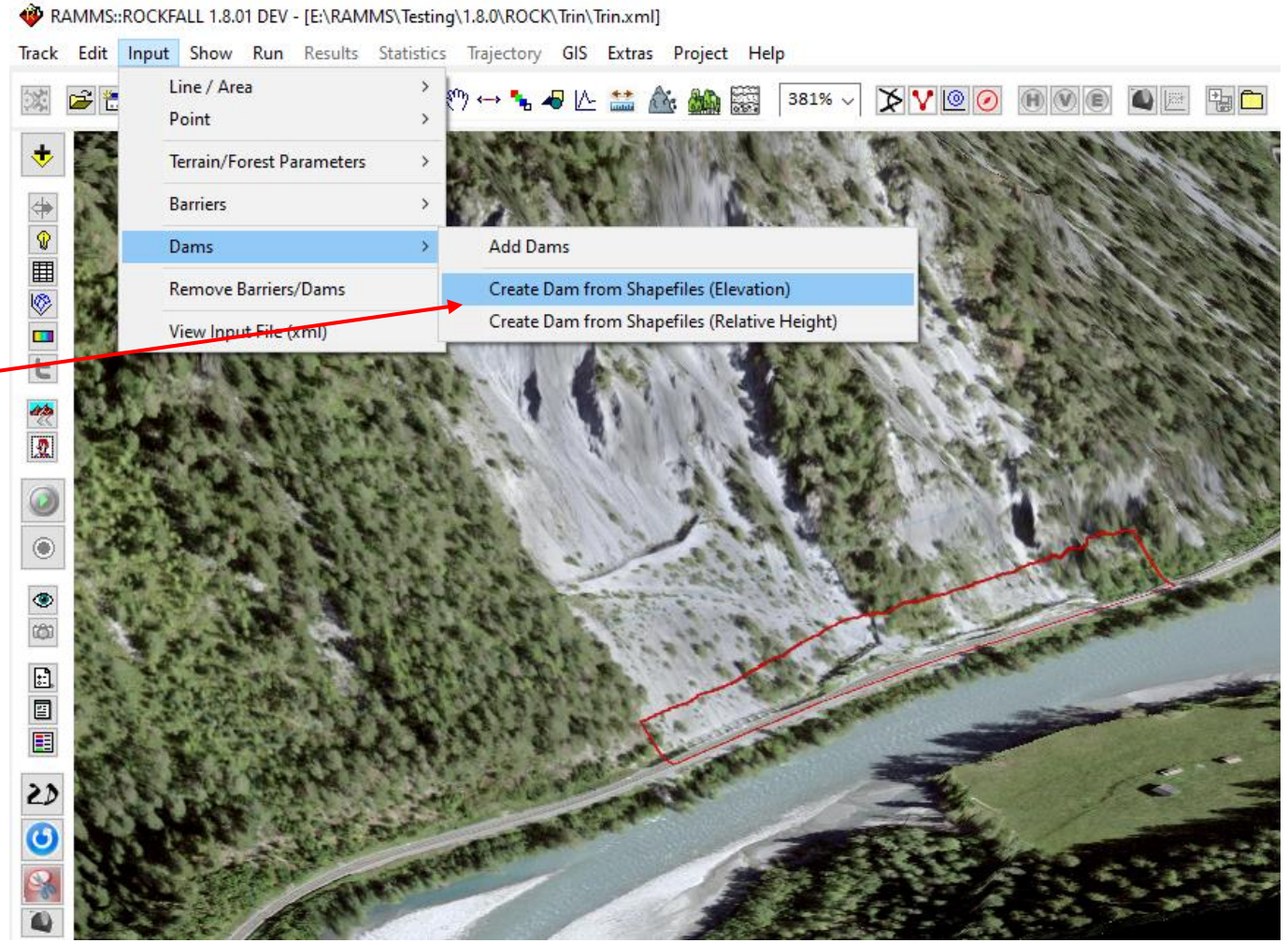


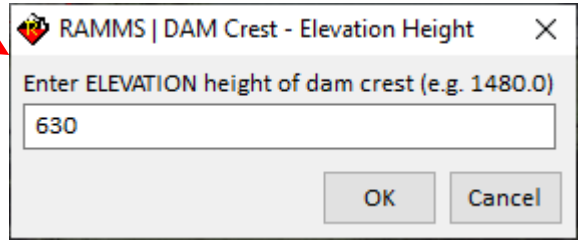
Dam foot shapefile



Galleries and Dams

- Use one of the two functions to either draw a dam/gallery with
  - a constant altitude
  - or a relative height
- Choose dam foot and dam crest shapefiles (use twice the same outline shapefile for a gallery)
- Then enter dam <u>elevation</u> or <u>relative</u> height

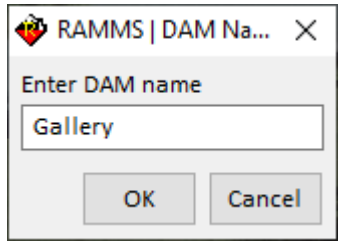




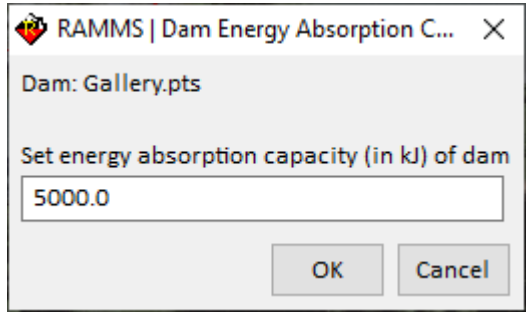
Galleries and Dams

Then enter

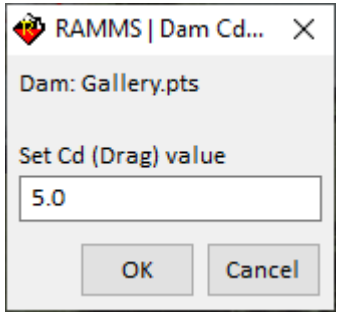
- Dam Name



- Energy absorption capacity (in kJ)



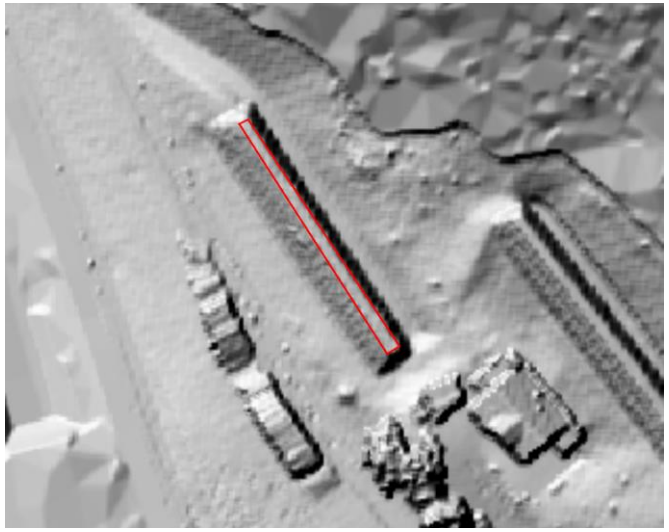
- And Cd



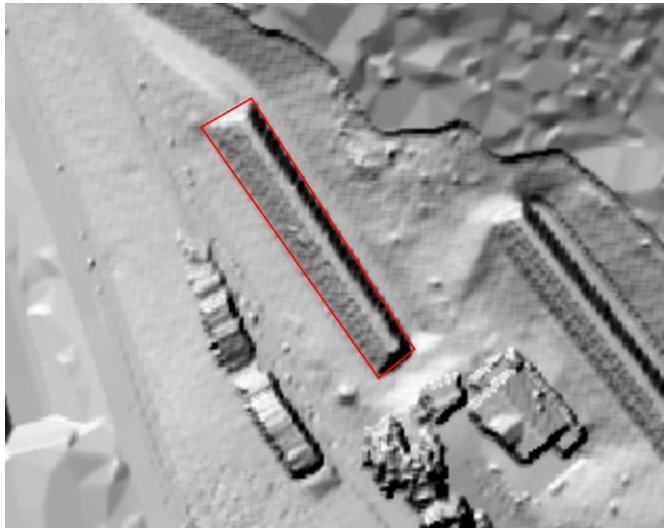
Galleries and Dams

- For a dam, the result would look something like this:

Dam crest shapefile



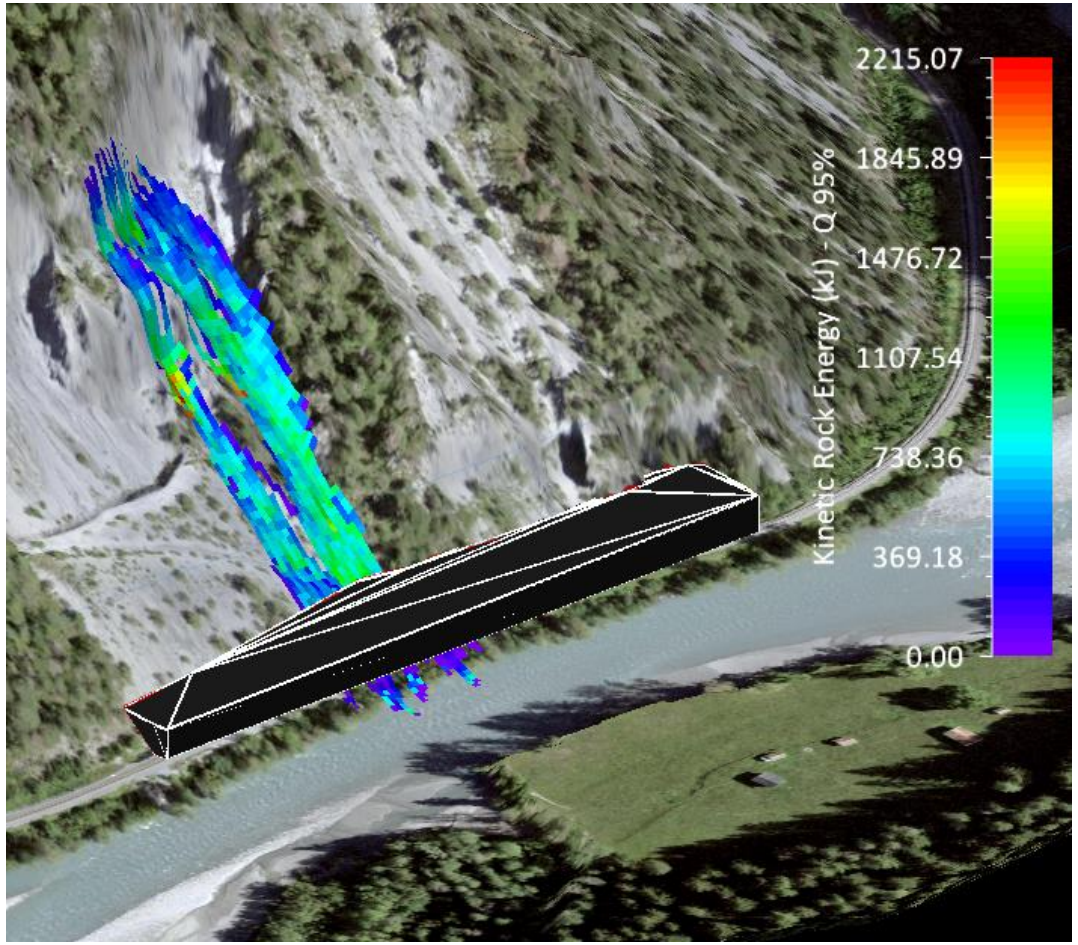
Dam foot shapefile



Gallery Analysis

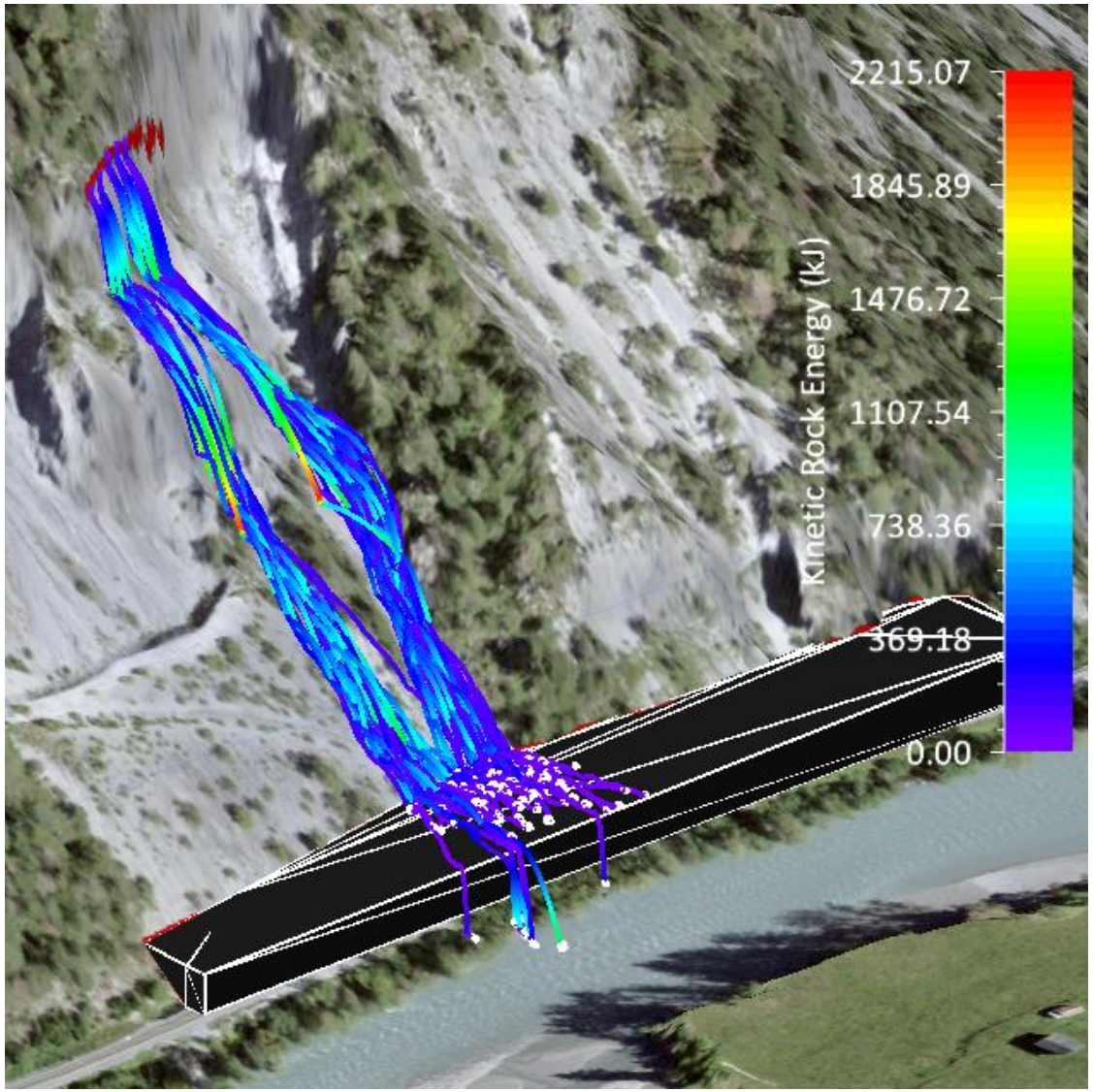
Analysing gallery results

- In *Statistic-Mode*, results look strange at first glance, but that's because results are projected onto the terrain, and not onto the gallery.



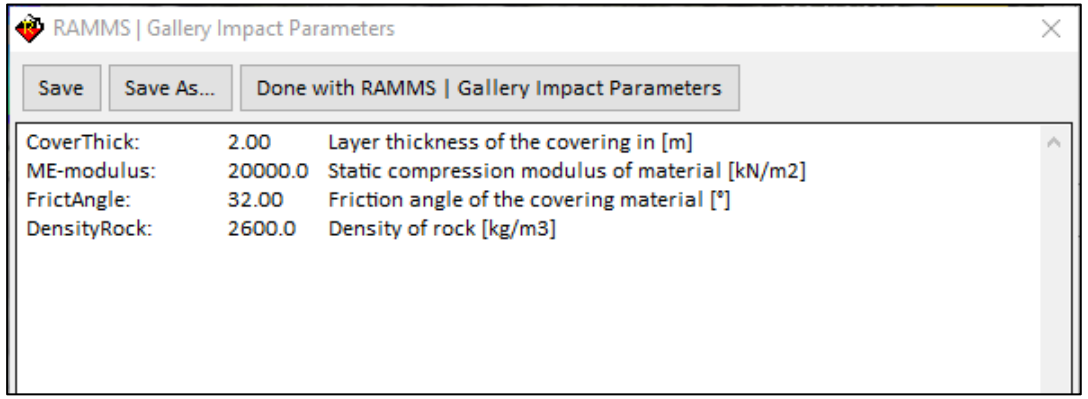
Gallery Analysis

- In *Trajectory-Mode*, the results look good!
- To analyse the results further, click
  «Extras → Analyse Gallery Impacts»



Gallery Analysis

- Enter *Gallery Impact Parameters* (click ***Save*** and ***Done***)
- RAMMS then analyses the impact values and calculates:
  - Impact angle (on flat plane)
  - Velocity before impact
  - Velocity after impact
  - Kin. Energy before impact
  - Kin. Energy after impact
  - Force Richtlinie
  - Normal Force Richtlinie
  - Tangential Force Richtlinie
  - Scar-Depth Richtlinie



Gallery Analysis

Richtlinie Ausgabe 2008 V2.03

Einwirkungen infolge Steinschlags auf Schutzgalerien

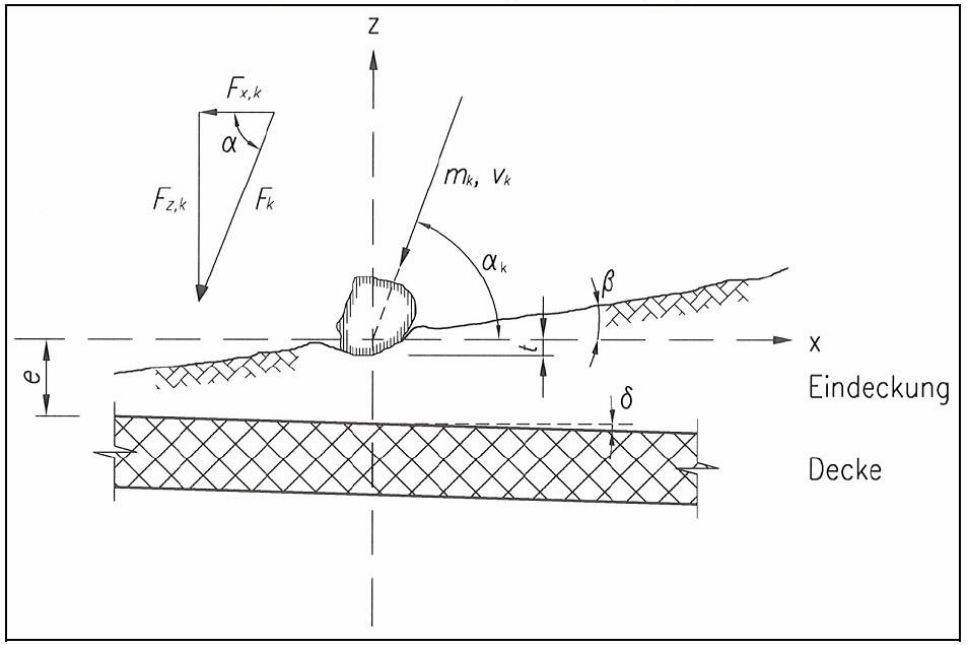
ASTRA

Gemäss Richtlinie können wir

- Eindringtiefe **t** [m] sowie
- Kraft am Aufprallort **F_k** [kN]

berechnen mithilfe

- Masse des Steinblocks m_k [t] — *Simulation*
- Radius der Ersatzkugel r [m] — *Simulation*
- Aufprallgeschwindigkeit v_k [m/s — *Simulation*
- Schichtstärke der Eindeckung e [m] — *Eingabe*
- statischen ME -Moduls des Eindeckungs-materials ME_k [kN/m2] — *Eingabe*
- Reibungswinkels des Eindeckungs-materials ϕ_k [°] — *Eingabe*



Die Kraft F_k und die Eindringtiefe t werden wie folgt ermittelt:

$$F_k = 2{,}8 \cdot e^{-0{,}5} \cdot r^{0{,}7} \cdot M_{E,k}{}^{0{,}4} \cdot \tan \varphi_k \cdot \left(\frac{m_k \cdot v_k{}^2}{2} \right)^{0{,}6}$$

$$t = \left(\frac{m_k \cdot v_k{}^2}{F_k} \right)$$

RAMMS | Barrier Impact Parameters

Save | Save As... | Done with RAMMS | Barrier Impact Parameters

CoverThick:	2.00	Layer thickness of the covering in [m]
ME-modulus:	20000.0	Static compression modulus of material [kN/m2]
FrictAngle:	32.00	Friction angle of the covering material [°]
DensityRock:	2600.0	Density of rock [kg/m3]

Gallery Analysis

- Only the **FIRST** impact of each rock trajectory on the gallery is used for the analysis (assumption: subsequent impacts are less severe)

- RAMMS creates point shapefile with all impacts with key attributes (impact force, angle, speed, etc.)

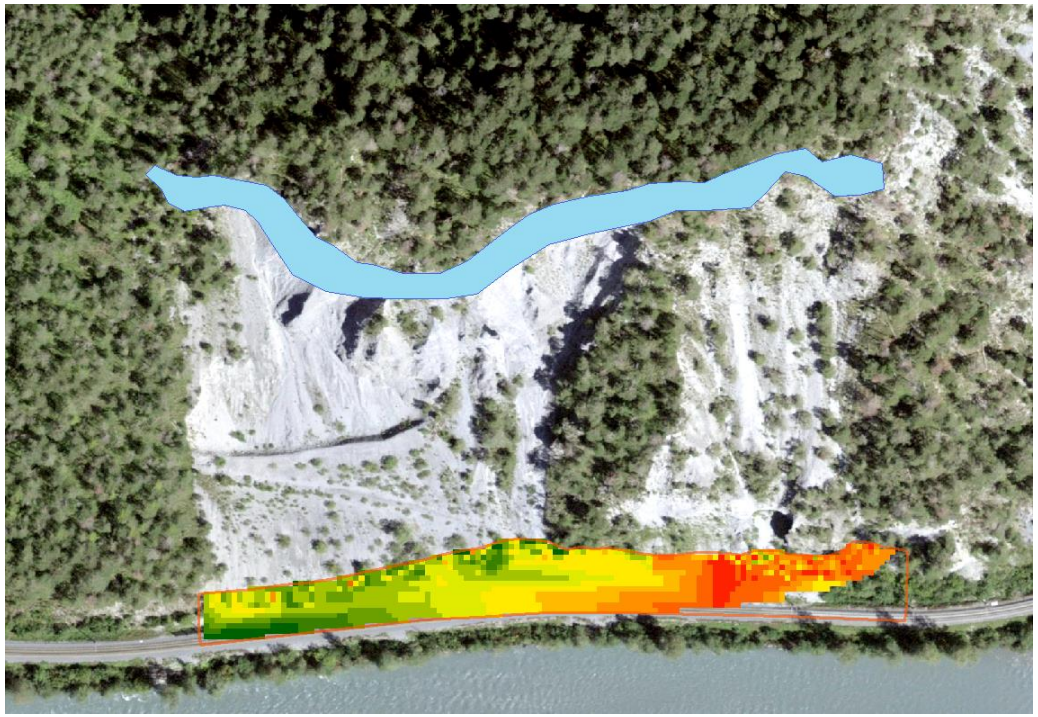
- Additionally, RAMMS creates two raster files (GeoTIFF, linear interpolation):
  - Distribution of Impact-Force F_k (by Richtlinie) over gallery-area
  - Distribution of scar-depth (by Richtlinie) over gallery-area

FID	Shape	Id	t (s)	Angle (°)	Vres pre (	Ekin pre (	F_R (kN)	Pen_R (m)
0	Point	0	12.433	57.075	31.634	2976.6	6325.5	0.855
1	Point	1	12.489	58.927	28.429	2458.6	5564.6	0.785
2	Point	2	13.501	61.955	23.004	1602	4316	0.6627
3	Point	3	13.977	64.94	25.653	1950.5	4919	0.7231
4	Point	4	12.567	31.467	19.748	1498.3	3593.7	0.5865
5	Point	5	13.191	60.229	29.69	2630	5861.9	0.8127
6	Point	6	13.447	59.857	25.546	1986.7	4894.3	0.7206
7	Point	7	12.087	51.942	29.848	2715.3	5899.4	0.8162
8	Point	8	13.649	52.357	26.963	2291.8	5221.9	0.7524
9	Point	9	11.497	52.067	29.999	2774.5	5935.4	0.8195
10	Point	10	17.581	52.846	13.746	562	2325.4	0.4389
11	Point	11	13.217	27.506	19.217	1254.7	3476.2	0.5738
12	Point	12	12.675	54.626	31.686	2980.3	6334.7	0.8561
13	Point	13	13.189	51.073	27.671	2287.5	5384.2	0.7681
14	Point	14	13.227	54.642	27.447	2179.8	5332.1	0.7632
15	Point	15	14.725	59.233	23.525	1555.6	4431.4	0.6746
16	Point	16	13.437	60.269	27.938	2291.7	5446.7	0.7741
17	Point	17	14.117	55.401	29.369	2534.6	5783.2	0.8056
18	Point	18	14.193	56.917	25.728	1894.7	4933.7	0.7247
19	Point	19	18.893	25.382	15.885	769.4	2766.1	0.4927
20	Point	20	11.835	56.344	29.58	2618.3	5835.9	0.8103
21	Point	21	12.781	55.906	26.022	2036.9	5004	0.7314
22	Point	22	11.049	32.828	22.17	1718.8	4128.9	0.6434
23	Point	23	13.387	56.268	27.912	2515.8	5443.4	0.7736
24	Point	24	13.057	56.956	27.197	2221.2	5276.5	0.7577
25	Point	25	12.669	22.757	14.64	769.02	2509.4	0.4616
26	Point	26	11.615	57.744	26.785	2217.9	5180.6	0.7485
27	Point	27	12.305	62.17	30.303	2631.1	6007.6	0.8261
28	Point	28	11.705	55.392	29.982	2704.9	5931.2	0.8191
29	Point	29	14.711	62.707	26.636	2025.9	5143.6	0.7451
30	Point	30	14.017	26.048	15.191	743.7	2621.9	0.4754
31	Point	31	11.971	56.328	29.622	2667.8	5842.9	0.8112
32	Point	32	11.383	60.678	28.705	2545.9	5626.7	0.791
33	Point	33	14.865	61.196	23.525	1574.2	4431.4	0.6746
34	Point	34	17.669	39.397	12.502	514.7	2075.3	0.4068
35	Point	35	14.315	42.145	11.106	364.88	1800.3	0.37

Raster - Results

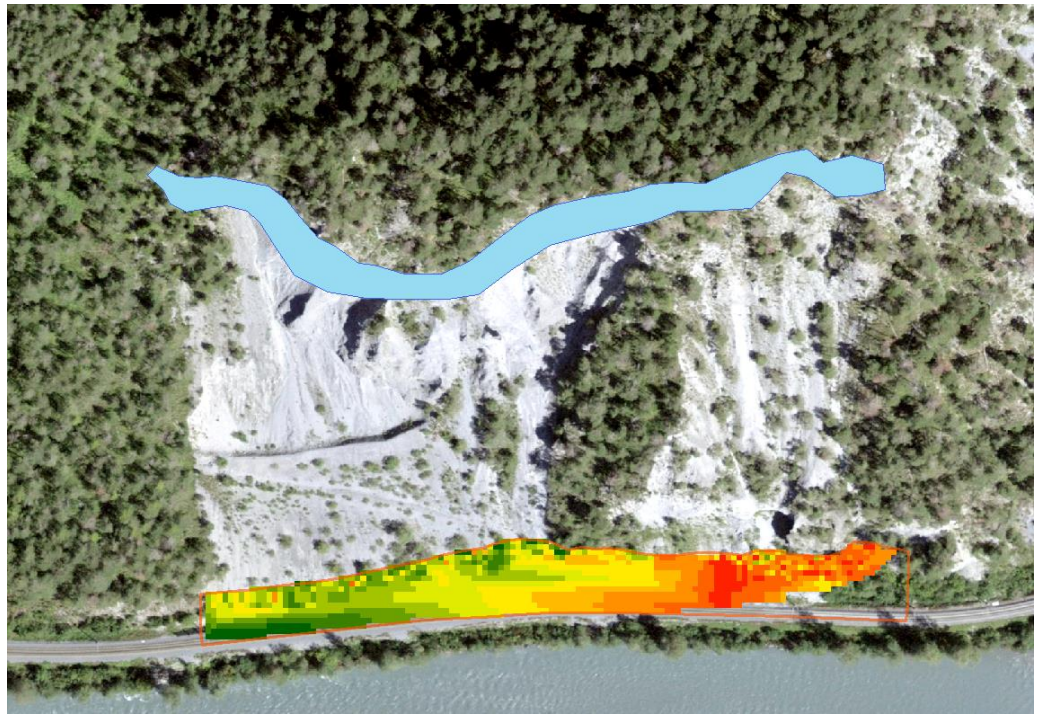
Release area

Gallerie-Outline



Impact-Force F_k (kN)

- 350.4264221 - 545.3913999
- 545.3914 - 697.7077888
- 697.7077889 - 819.5608999
- 819.5609 - 947.5066666
- 947.5066667 - 1'087.637744
- 1'087.637745 - 1'233.861478
- 1'233.861479 - 1'386.177867
- 1'386.177868 - 1'538.494256
- 1'538.494257 - 1'702.995956
- 1'702.995957 - 1'904.053589



Scar-Depth (m)

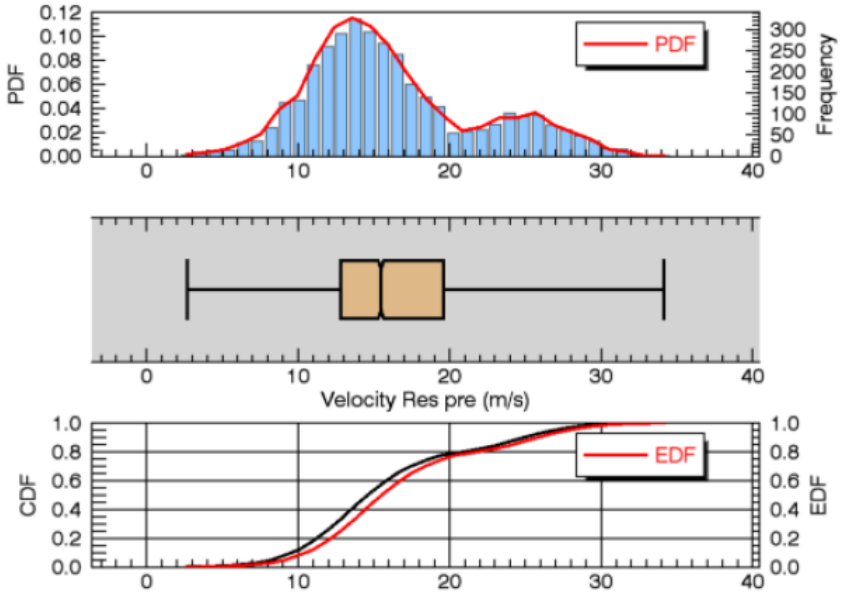
- 0.20599699 - 0.280609051
- 0.280609051 - 0.33390338
- 0.33390338 - 0.372985888
- 0.372985888 - 0.408515441
- 0.408515441 - 0.445821471
- 0.445821471 - 0.483127501
- 0.483127501 - 0.523986487
- 0.523986487 - 0.56662195
- 0.56662195 - 0.607480936
- 0.607480936 - 0.658998787

Impact - Statistics

Create Gallery-PDF-Report to view these statistics-plots

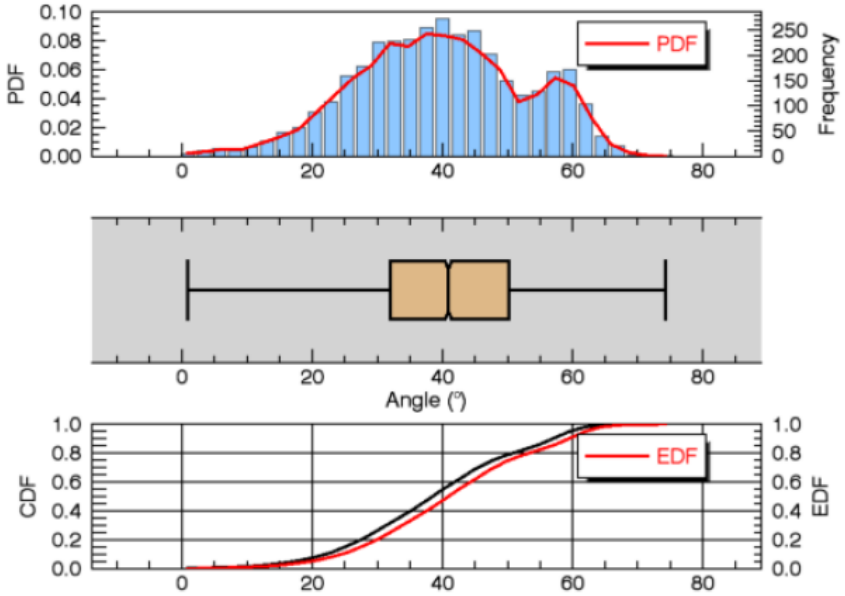
Velocity Res pre (m/s) - Statistics Summary:

Parameter: Velocity Res pre (m/s)
Min / Max: 2.68 / 34.15
Mean / Median: 16.71 / 15.47
Std Dev: 5.66
Q1 / Q3 / IQR: 12.80 / 19.56 / 6.76
Q90 / Q95 / Q99: 25.83 / 27.74 / 30.72
Nr of data values: 3547
Histogram bin size: 0.90



Angle (°) - Statistics Summary:

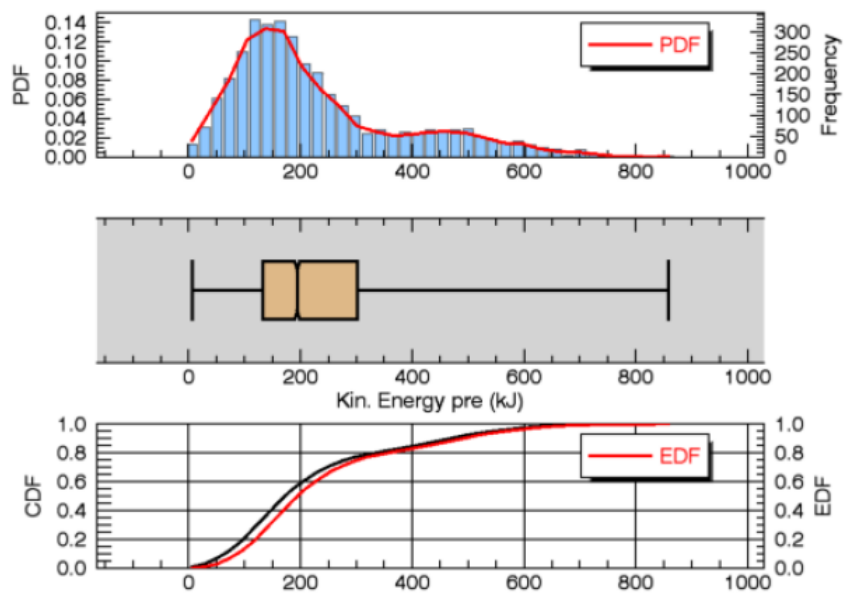
Parameter: Angle (°)
Min / Max: 0.85 / 74.28
Mean / Median: 41.09 / 40.92
Std Dev: 13.00
Q1 / Q3 / IQR: 32.04 / 50.21 / 18.17
Q90 / Q95 / Q99: 59.40 / 61.82 / 66.25
Nr of data values: 3547
Histogram bin size: 2.37



Impact - Statistics

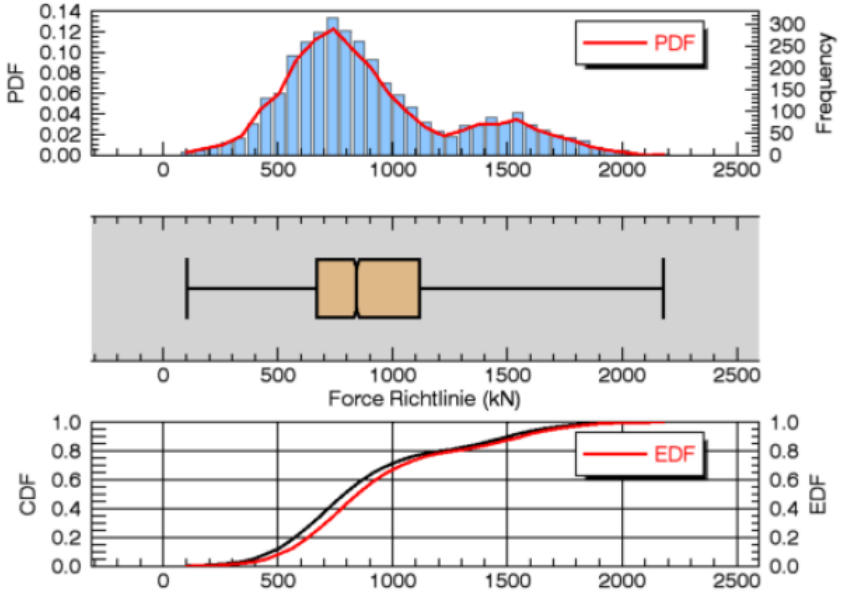
Kin. Energy pre (kJ) - Statistics Summary:

Parameter: Kin. Energy pre (kJ)
Min / Max: 6.31 / 858.80
Mean / Median: 240.74 / 194.38
Std Dev: 153.94
Q1 / Q3 / IQR: 133.10 / 302.37 / 169.27
Q90 / Q95 / Q99: 492.94 / 564.70 / 682.29
Nr of data values: 3547
Histogram bin size: 21.86



Force Richtlinie (kN) - Statistics Summary:

Parameter: Force Richtlinie (kN)
Min / Max: 102.86 / 2180.26
Mean / Median: 937.23 / 842.64
Std Dev: 381.45
Q1 / Q3 / IQR: 671.22 / 1116.99 / 445.77
Q90 / Q95 / Q99: 1558.98 / 1698.68 / 1919.77
Nr of data values: 3547
Histogram bin size: 56.15



Rockfall Net

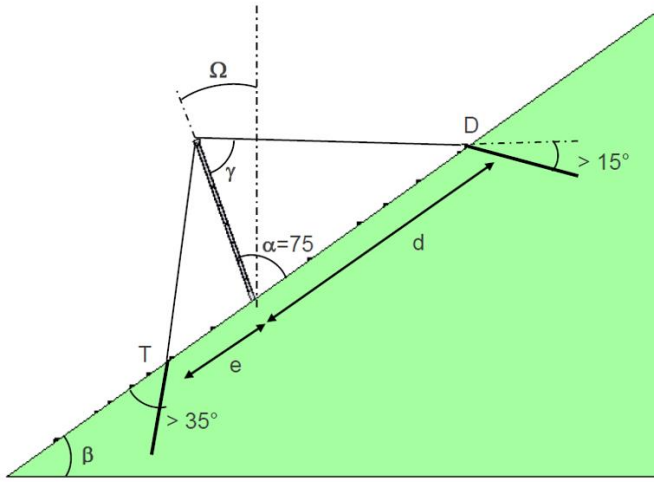
Remarks:

- We do not model nets as real nets, but as “**thin walls**”, as rigid obstacles.
- Like galleries, these “**thin walls**” are modeled as convex hulls (point cloud).
- That's why a separate net is created from support to support (Stütze).

- “Nets” can be created interactively in RAMMS (by drawing lines) or created from existing polyline shapefiles.

Rockfall Nets – Support Angle

The angle (α) between the support and the terrain can be defined according to this sketch from Geobrugg.

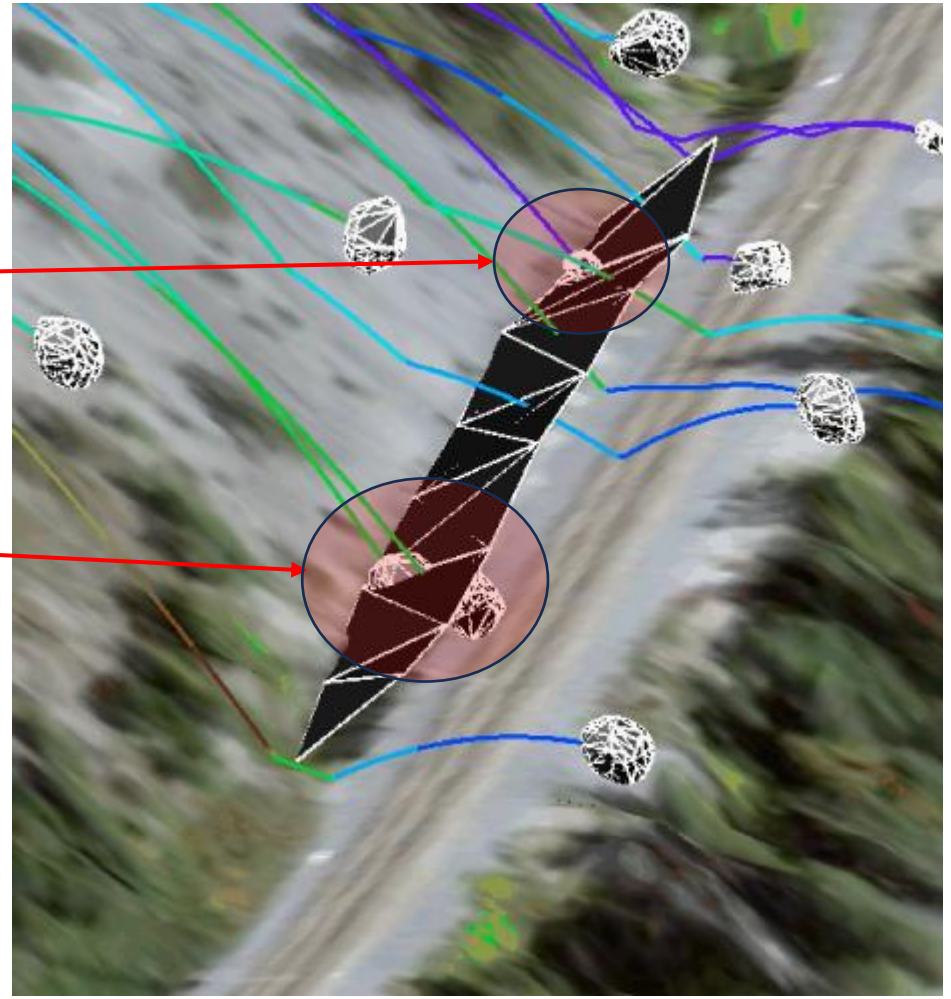


α = 90 °

Rockfall Nets – Energy Absorption Capacity

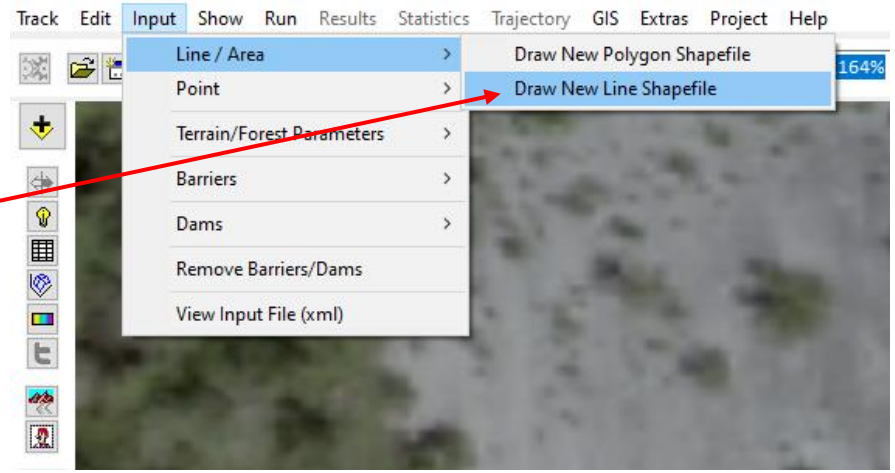
For each net, a maximum kinetic energy absorption capacity (1’000 kJ in the example on the right) can be defined. If the kinetic energy of the rock is lower than this limit, the rock is stopped.

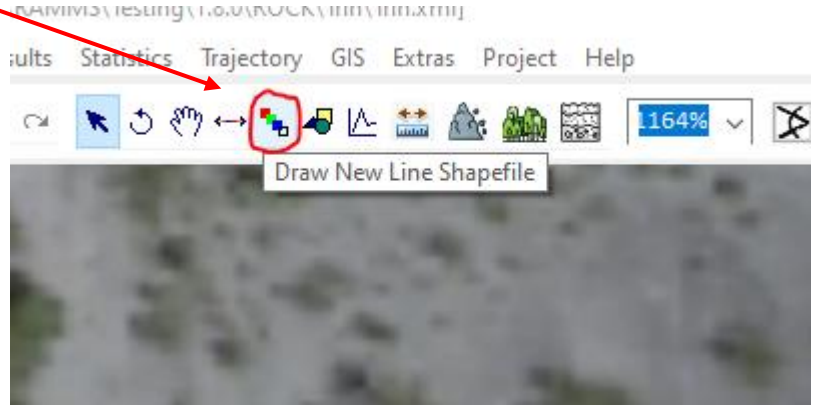
If this limit value is exceeded by the rock, the net has no influence on the rock’s trajectory.



Rockfall Net - Example

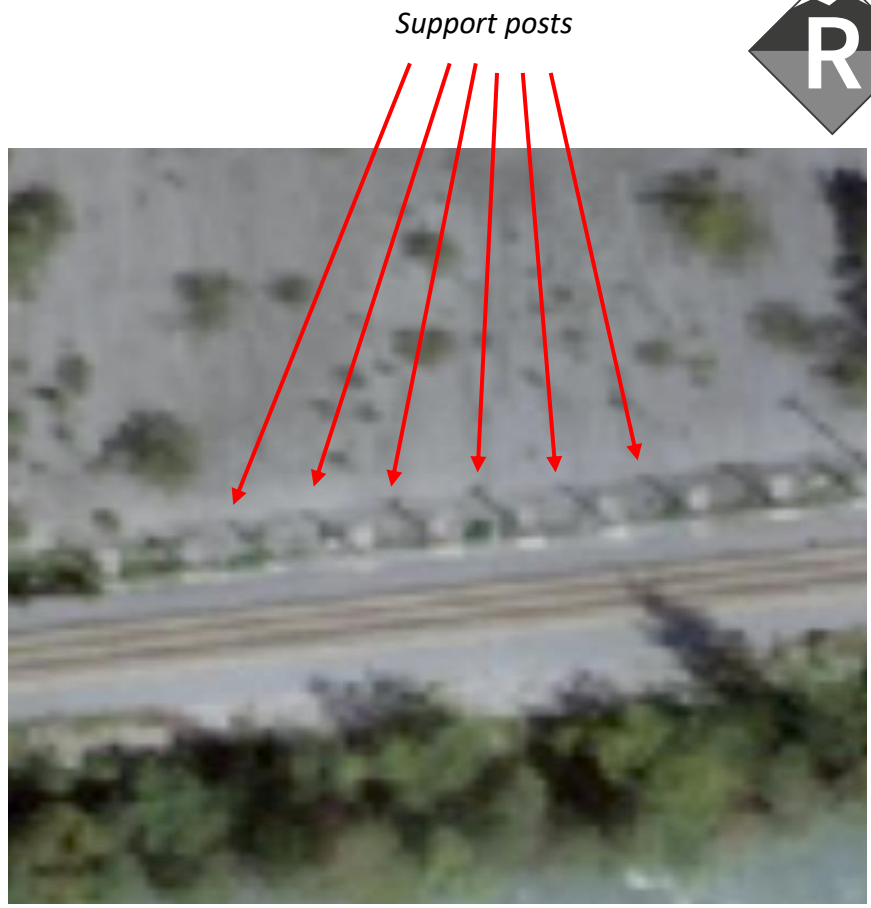
- Draw line shapefile at location of rockfall net.
- Click at positions of support posts.





Rockfall Net - Example

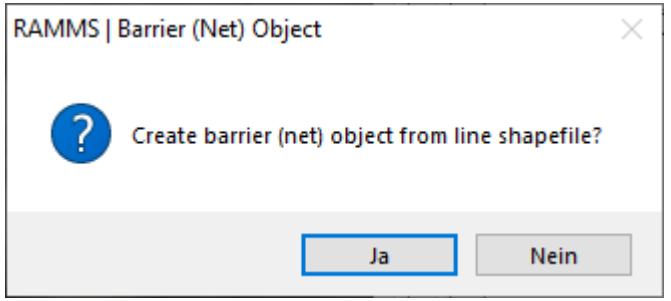
- While drawing the line shapefile, RAMMS indicates the distance from the mouse pointer to the last click.

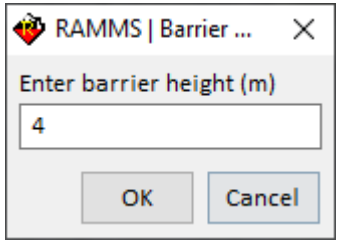


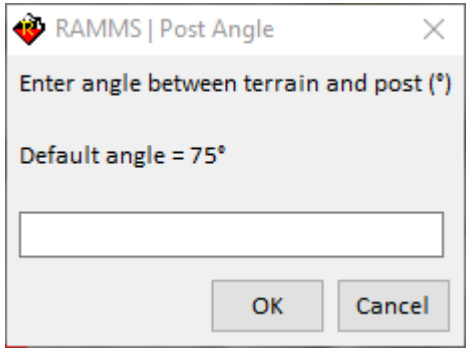
Rockfall Net - Example

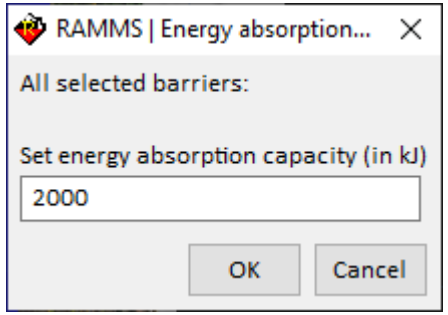
- Finish drawing line shapefile with right mouse click.
- Draw more lines if needed within the same shapefile.
- Give a meaningful name.
- Click *Yes* to create net object.
- Enter barrier (net) height in (m).
- Enter angle between terrain and posts.

Now you can define an energy absorption capacity for every single net (one net between two posts).









Rockfall Net - Example

- The net objects are then visualized in RAMMS.
- Remove all barrier objects with *«Input → Remove Barriers/Dams»*