



Understanding RAMMS Outputs: Statistics Mode vs Trajectory Mode

Interpreting rockfall simulations for engineering analysis

Marc Christen and Perry Bartelt
RAMMS AG, Davos Wiesen, Switzerland

Statistics Mode vs Trajectory Mode



RAMMS rockfall simulations produce **thousands of trajectories**.

Statistics Mode answers: What is the representative impact in this location?

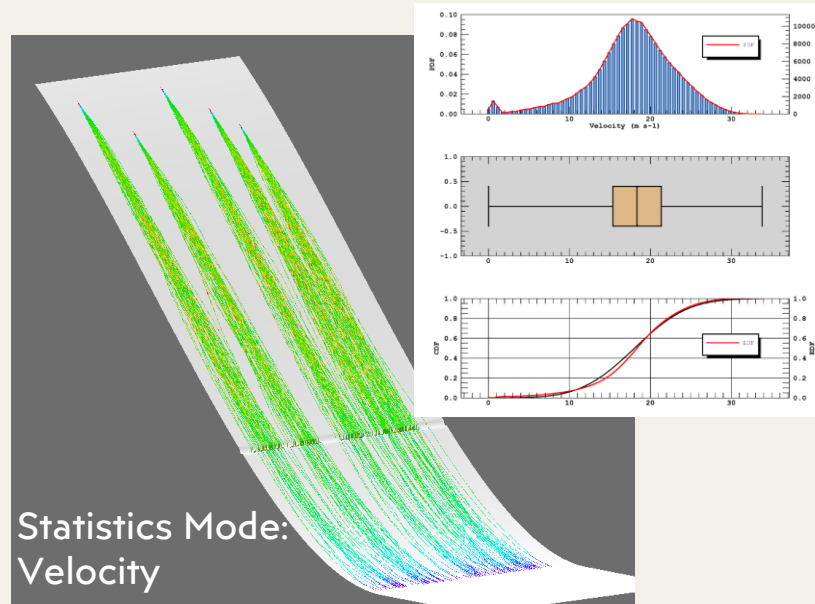
Trajectory Mode answers: What actually happened to individual rocks?

Statistics Mode

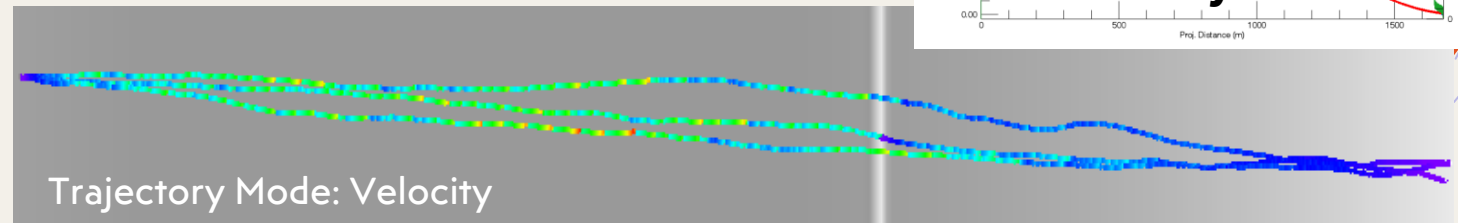
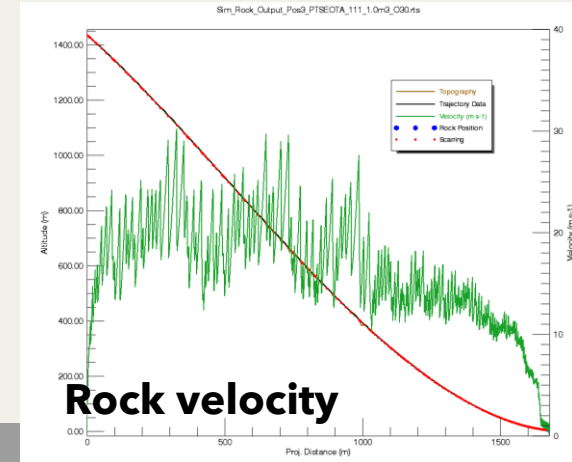
- Evaluates **all trajectories together**
- Results stored **per raster cell**
- Produces **hazard maps**
- Used for **engineering design**

Trajectory Mode

- Shows **individual rock paths**
- Used to inspect **specific events**
- Useful for **debugging** or **interpretation**



Statistical distribution PDF/CDF
kinetic energy Q95 map
jump height map
reach probability



Statistics Mode: Cell-Based Data Storage

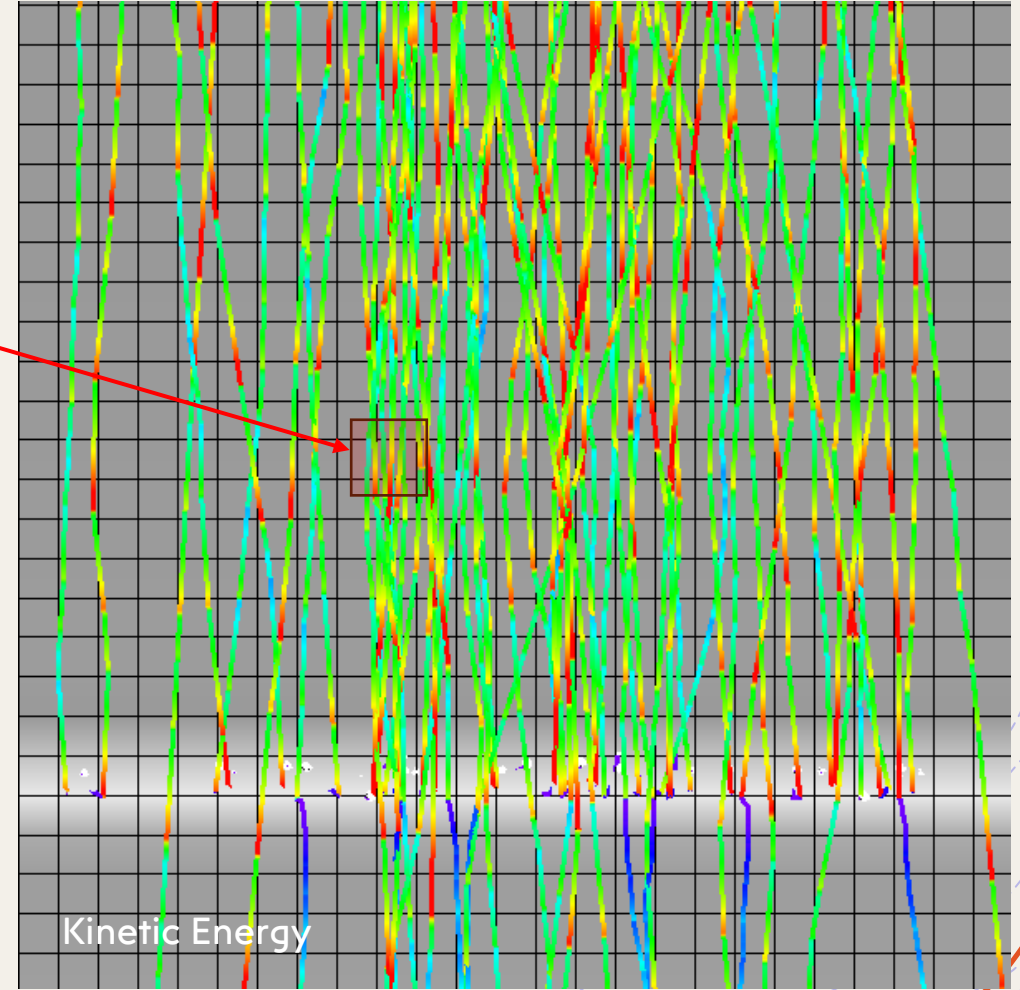


For every raster cell intersected by trajectories, RAMMS stores:

- Jump height (H)
- Translational velocity (V)
- Rotational velocity
- Kinetic energy (E)
- Scar length
- Scar depth

Example: Kinetic energy
 $E = 25, 30, 32, 40, 45, \dots, 120 \text{ kJ}$

Each value becomes **one sample in the statistical distribution** of that cell. Statistics are computed from this **sample set**.



All 34 Data Values (+ Output File Name):

JumpH	Vel	KinE	RotV	Filename
3.25	18.90	589.44	3.07	Example_Pos14_PTSReal_Flat_1.77_1.0m3_O17.rts
1.86	11.43	197.95	1.42	Example_Pos14_PTSReal_Flat_1.77_1.0m3_O4.rts
0.76	4.19	31.25	0.92	Example_Pos15_PTSReal_Flat_1.77_1.0m3_O2.rts
3.13	11.61	219.55	1.77	Example_Pos19_PTSReal_Flat_1.77_1.0m3_O6.rts
3.20	13.36	300.68	2.65	Example_Pos19_PTSReal_Flat_1.77_1.0m3_O8.rts
2.12	9.09	143.55	1.82	Example_Pos22_PTSReal_Flat_1.77_1.0m3_O18.rts
1.16	24.07	882.32	3.03	Example_Pos25_PTSReal_Flat_1.77_1.0m3_O1.rts
0.54	25.54	1033.67	3.64	Example_Pos25_PTSReal_Flat_1.77_1.0m3_O20.rts
2.14	10.52	172.44	1.51	Example_Pos25_PTSReal_Flat_1.77_1.0m3_O23.rts

Trajectory values stored for one raster cell.

Descriptive Statistics per Cell



Save Save As... OK


Grid Cell Values Summary

Date: Thu Jul 10 20:58:27 2025
Grid Cell Nr: 69570
Nr of Cell Values: 34

JumpH: JumpHeight (m) - Vel: Velocity (m/s) - KinE: KinEnergy (kJ) - RotV: RotVelocity (rot s-1)

Statistic Analysis of trajectory values below

Param	JumpH	Vel	KinE	RotV
Mean	2.05	15.56	477.41	2.28
Median	2.09	13.38	285.54	2.16
90%	3.87	25.93	1107.84	4.15
95%	6.50	34.88	1883.63	4.99
99%	6.50	34.88	1883.63	4.99
Max	6.50	34.88	1883.63	4.99

Cell is found by using info button: 

All 34 Data Values (+ Output File Name):

JumpH	Vel	KinE	RotV	Filename
3.25	18.90	589.44	3.07	Example_Pos14_PTSReal_Flat_1.77_1.0m3_O17.rts
1.86	11.43	197.95	1.42	Example_Pos14_PTSReal_Flat_1.77_1.0m3_O4.rts
0.76	4.19	31.25	0.92	Example_Pos15_PTSReal_Flat_1.77_1.0m3_O2.rts
3.13	11.61	219.55	1.77	Example_Pos19_PTSReal_Flat_1.77_1.0m3_O6.rts
3.20	13.36	300.68	2.65	Example_Pos19_PTSReal_Flat_1.77_1.0m3_O8.rts
2.12	9.09	143.55	1.82	Example_Pos22_PTSReal_Flat_1.77_1.0m3_O18.rts
1.16	24.07	882.32	3.03	Example_Pos25_PTSReal_Flat_1.77_1.0m3_O1.rts
0.54	25.54	1033.67	3.64	Example_Pos25_PTSReal_Flat_1.77_1.0m3_O20.rts
2.14	10.52	172.44	1.51	Example_Pos25_PTSReal_Flat_1.77_1.0m3_O23.rts

From each cell's sample set RAMMS computes:

Central tendency

- Mean
- Median (50% quantile)

Spread

- Standard deviation
- Interquartile range (IQR)

Extreme values

- Maximum

The **maximum** represents **only one trajectory** → not statistically robust.

Preferred design values

- Q90
- Q95
- Q99

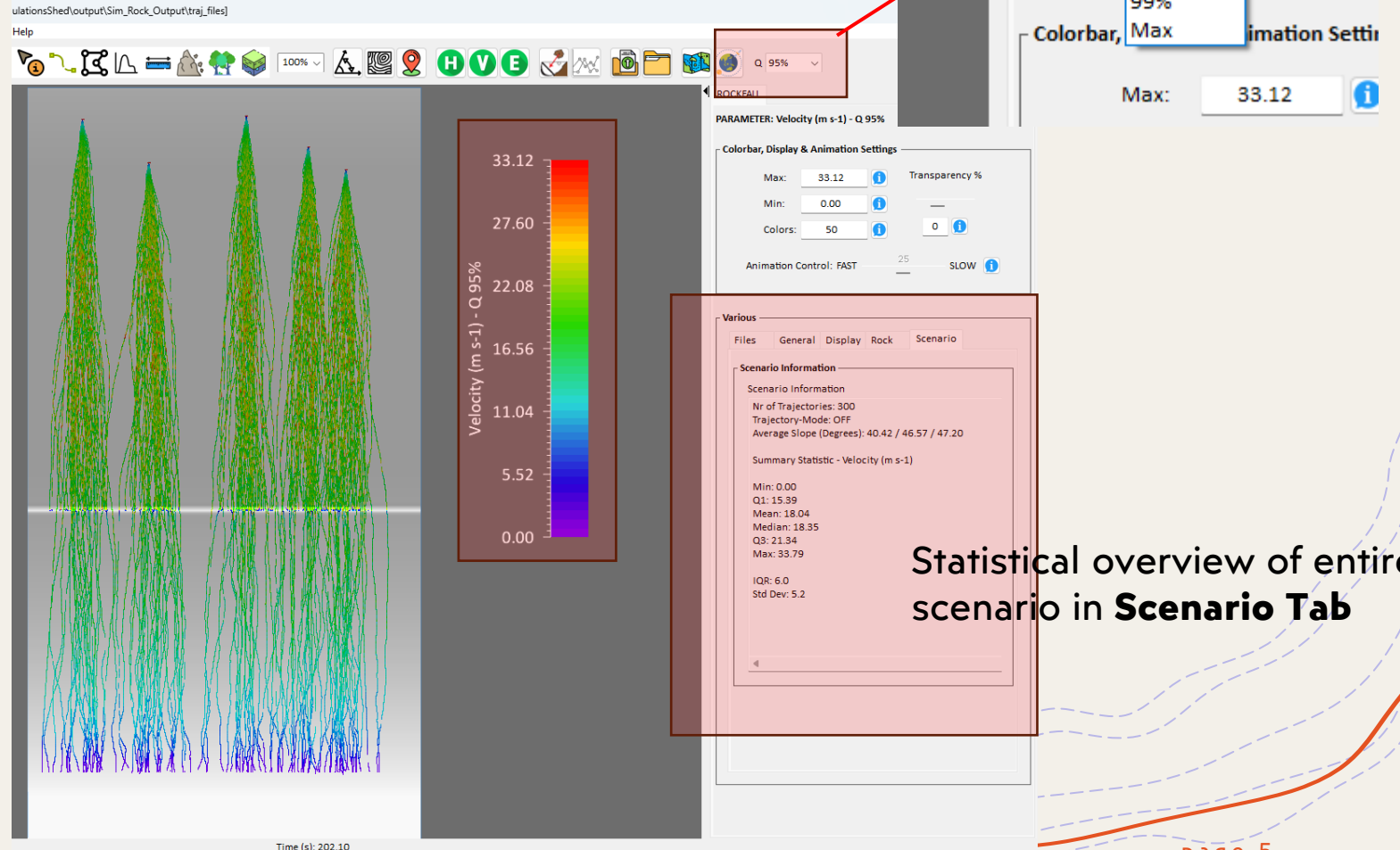
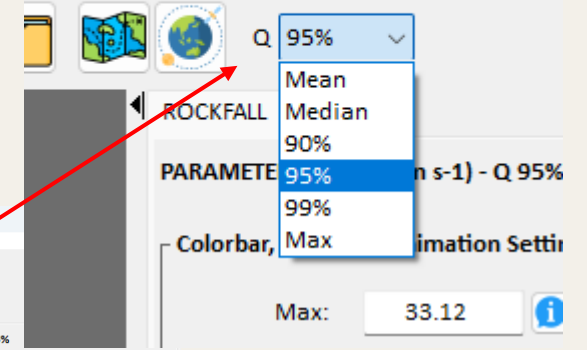
Statistical summary computed from trajectory samples.

Quantiles in RAMMS

Quantiles describe **impact levels exceeded by only a small fraction of rocks.:**

- Q90 90% of values are smaller
Only 5% exceed this value
- Q95
- Q99 Extreme impacts
25% are smaller
75% are smaller
- Q1
- Q3

Set visualization quantile



Statistical overview of entire scenario in **Scenario Tab**

Visualization of quantile Q95 for each cell

Histogram and Probability Density Function



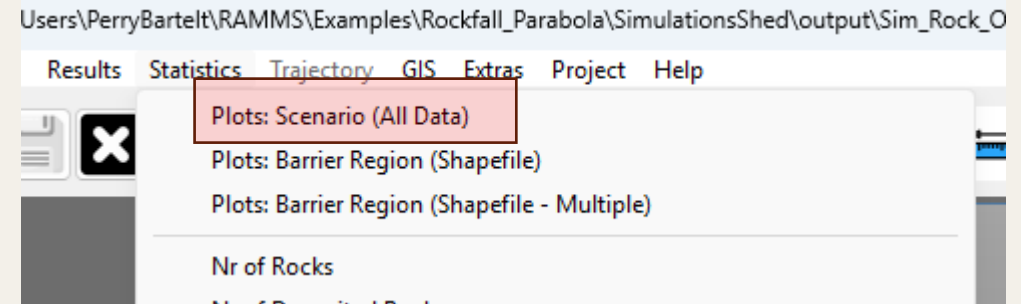
To understand the **shape of the data distribution**, RAMMS provides:

Histogram

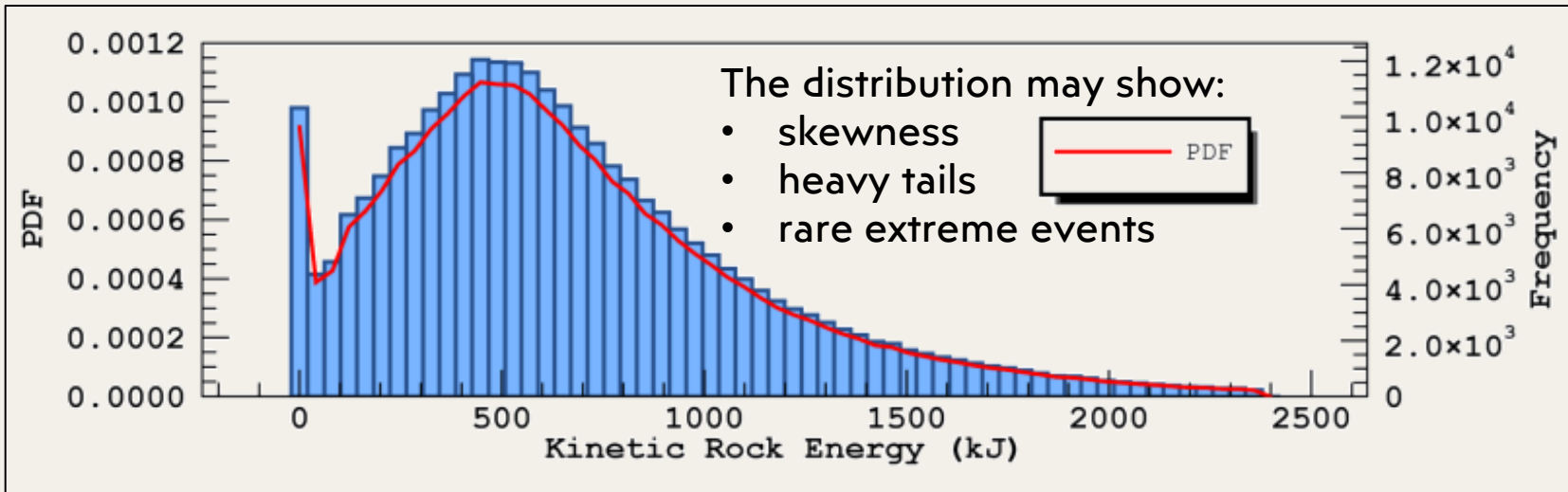
- Shows frequency of values

Probability Density Function (PDF)

- Normalized distribution
- Area under curve = 1



Use: *Statistics* → *Plots: Scenario (All Data)*



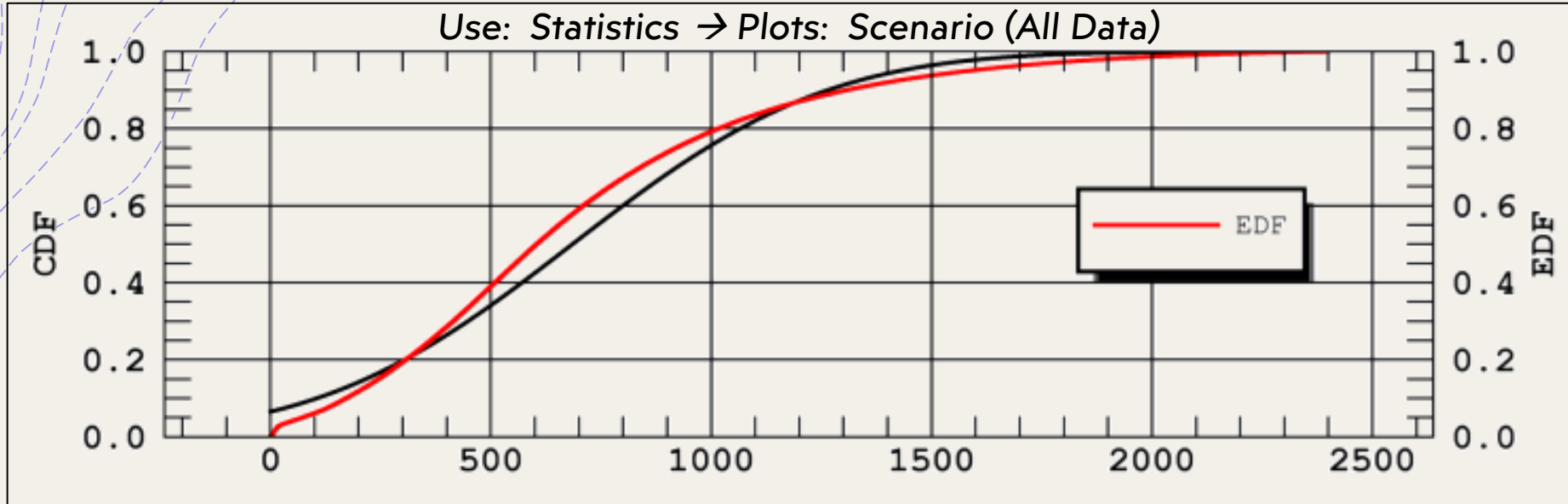
***.png are visualized with browser and
*.txt files are created with values.
Saved under .../reports/stat_plots**

File Name	Date	Type	Size
Scenario_JumpH_plot.png	3/11/2026 9:49 AM	PNG File	148 KB
Scenario_JumpH_stats.txt	3/11/2026 9:49 AM	Text Document	1 KB
Scenario_KinEnergy_plot.png	3/11/2026 9:49 AM	PNG File	149 KB
Scenario_KinEnergy_stats.txt	3/11/2026 9:49 AM	Text Document	1 KB
Scenario_Rotations_plot.png	3/11/2026 9:49 AM	PNG File	142 KB
Scenario_Rotations_stats.txt	3/11/2026 9:49 AM	Text Document	1 KB
Scenario_ScarDepth_plot.png	3/11/2026 9:49 AM	PNG File	137 KB
Scenario_ScarDepth_stats.txt	3/11/2026 9:49 AM	Text Document	1 KB
Scenario_Velocity_plot.png	3/11/2026 9:49 AM	PNG File	143 KB
Scenario_Velocity_stats.txt	3/11/2026 9:49 AM	Text Document	1 KB

CDF and EDF Distributions



Comparing EDF and Gaussian CDF helps identify **deviations from normal behavior**



***.png are visualized with browser and *.txt files are created with values. Saved under .../reports/stat_plots**

Empirical Distribution Function (EDF)

- Computed directly **from simulated trajectory values**
- Built from the **sorted sample data**
- Shows the **actual cumulative distribution** of the simulation results
- Step-shaped curve because it is based on discrete trajectory samples

Reference Cumulative Distribution Function (CDF)

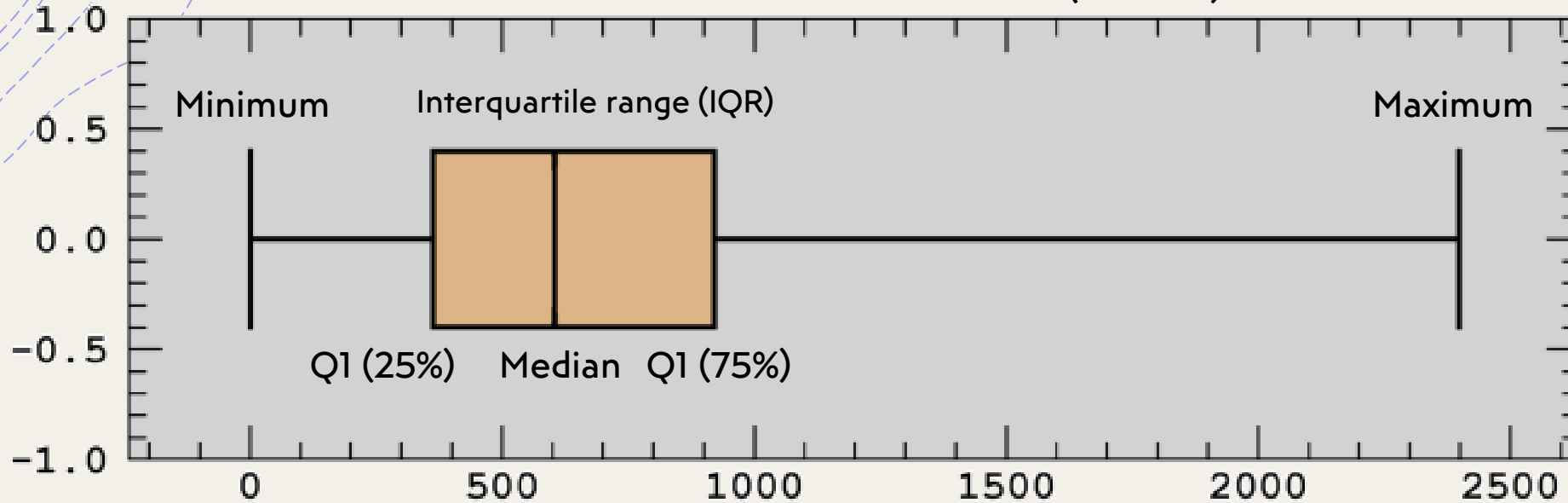
- **Theoretical distribution curve**
- RAMMS uses a **Normal (Gaussian) distribution**
- Defined by the sample **mean** and **standard deviation**
- Used only for visual comparison

Quick Summary of the Distribution



The statistical reports also contain box plots. These reveal skewed distributions, extreme outliers and variability. This helps evaluate **whether high quantiles are reliable**.

Use: Statistics → Plots: Scenario (All Data)



***.png are visualized with browser and *.txt files are created with values. Saved under .../reports/stat_plots**

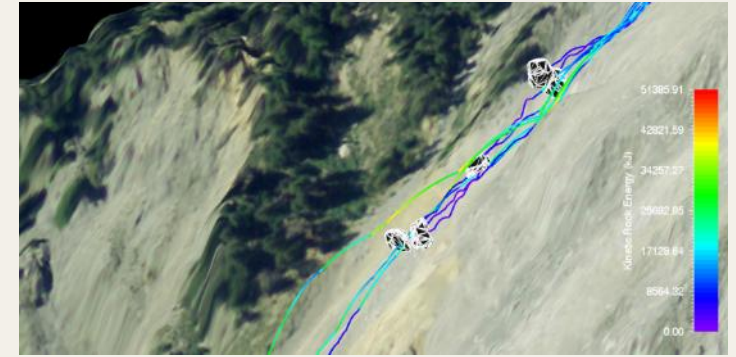
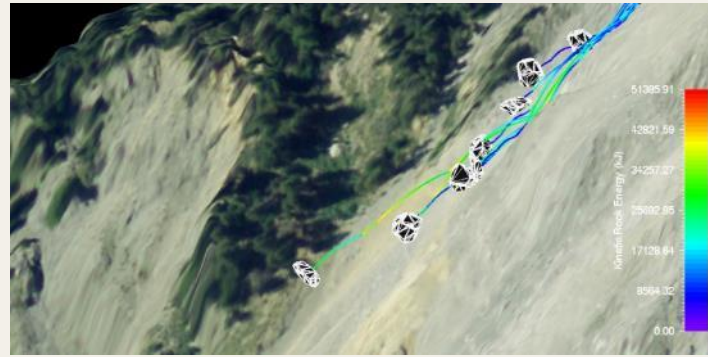
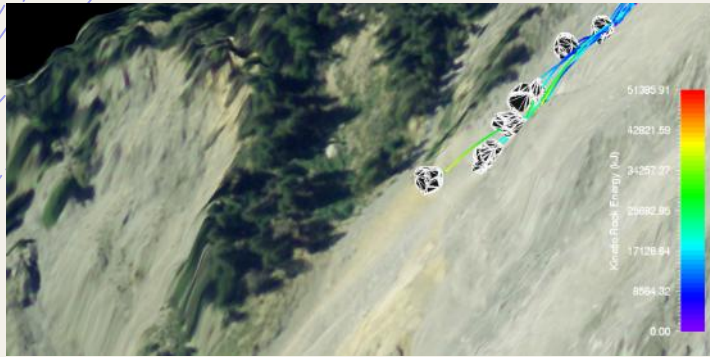
Boxplots summarize the distribution using:

- Q1 (25%)
- Median
- Q3 (75%)
- Interquartile range (IQR)
- Minimum / Maximum
- Outliers

Purpose of Trajectory Mode



Trajectory Mode allows **detailed inspection of individual rock paths**. Often used when investigating **barriers, sheds and dams**. Unlike Statistics mode, no statistical evaluation, focus is on **single trajectories**.



Trajectory Mode is useful to:

- Understand rock motion
- Investigate extreme events
- Verify unusual statistical results
- Visualize rockfall dynamics

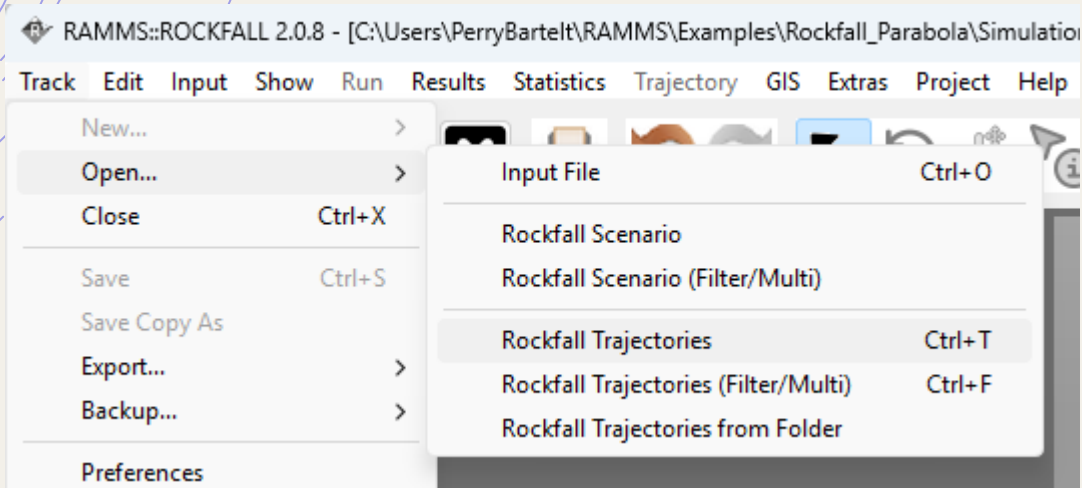
Typical questions:

- Why is the energy high at this location?
- How does a rock reach this area?
- Where do rocks impact the terrain?

Opening Trajectories in RAMMS

Option 1 – Open Individual Trajectories

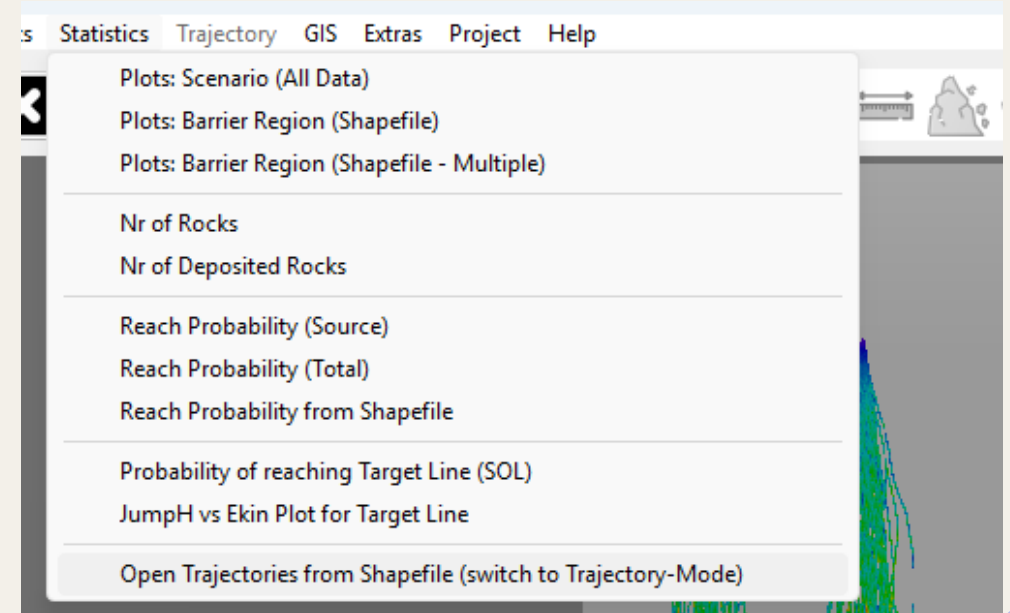
Track → Open → Rockfall Trajectories 



- Select trajectories from the **traj_files** folder
- Can open trajectories from one or multiple scenarios
- Filtering possible using **filename filters**
- **Recommendation:** Open ≤ 100 trajectories for smooth visualization.

Option 2 – Open Trajectories from Shapefile

Statistics → Open Trajectories from Shapefile



This feature selects only trajectories interacting **within a specific region**.

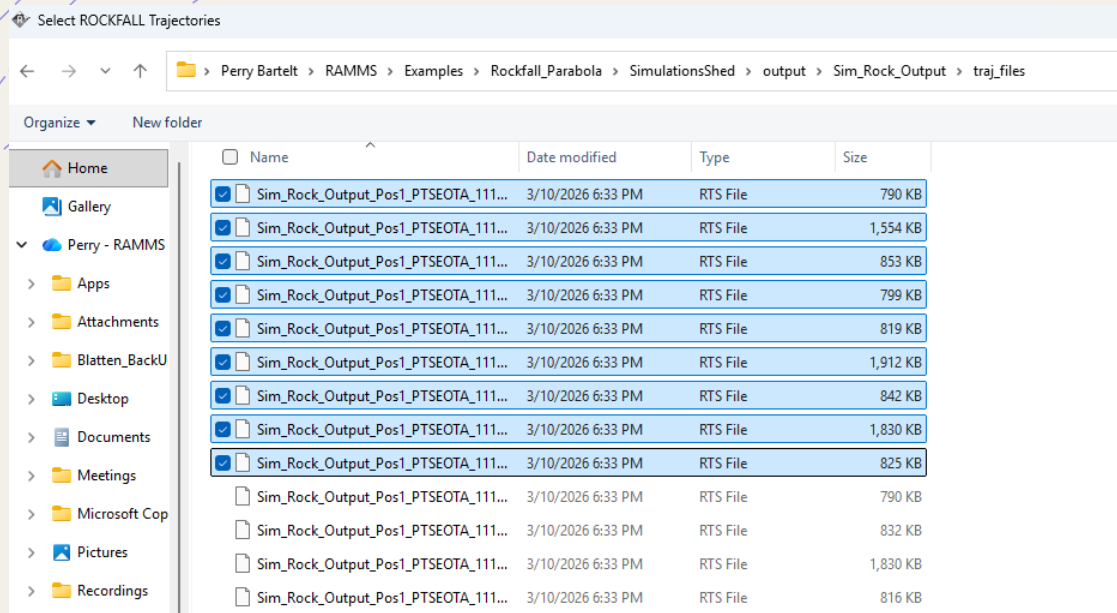
- Supported shapefiles:
- Polygon → e.g. **buildings, net fields, protection areas**
- Polyline → e.g. **roads, dams, protection lines**

Examples of Opening Trajectories



Option 1 – Open Individual Trajectories

After selecting *Track* → *Open* → *Rockfall Trajectories*, go to the *traj_files* folder and select the trajectory files (Ctrl-A selects all).

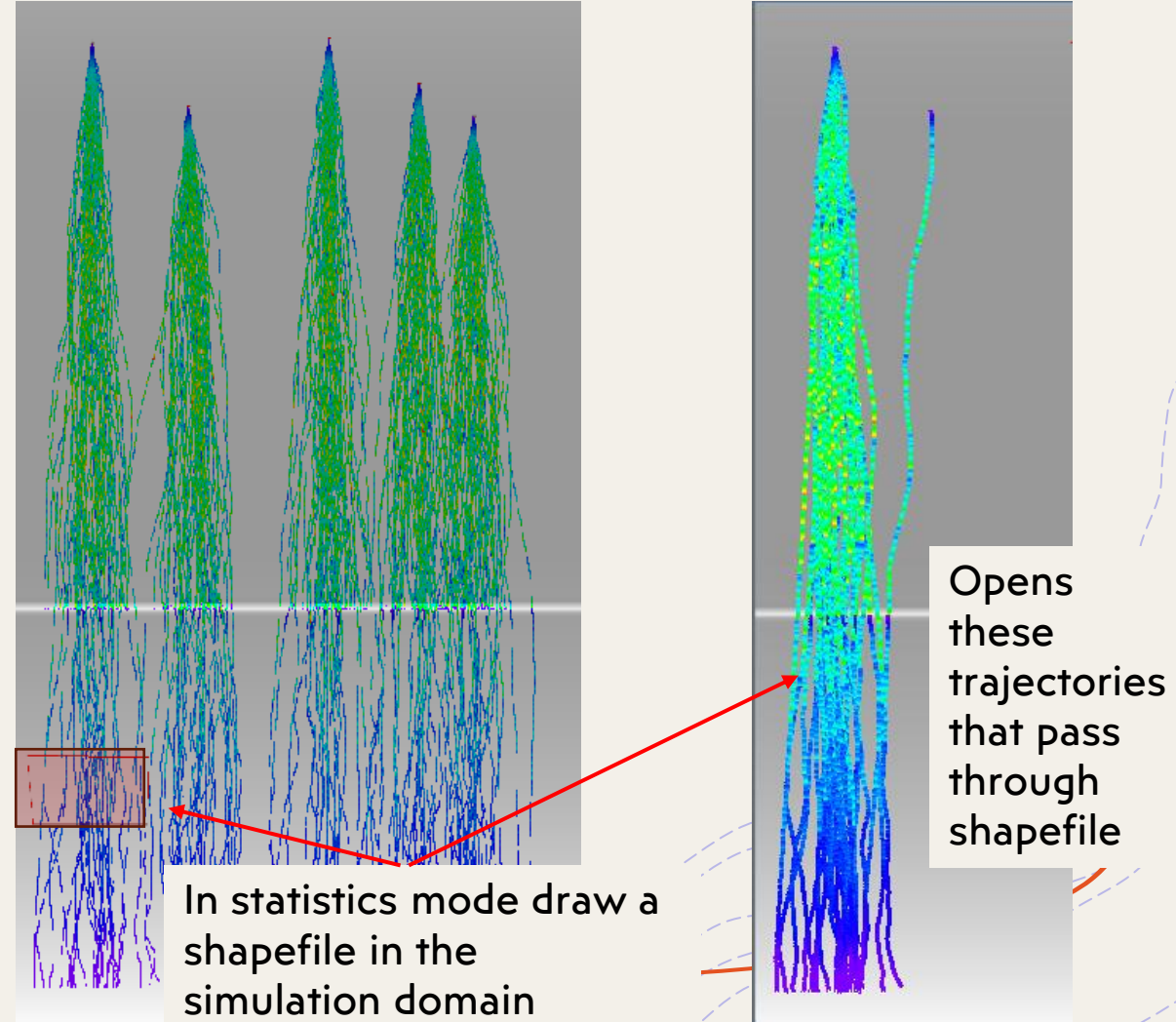


This tool allows engineers to:

- investigate rocks reaching a road or structure
- analyse extreme events at a specific location
- link statistical results to real trajectories

Option 2 – Open Trajectories from Shapefile

Statistics → *Open Trajectories from Shapefile*

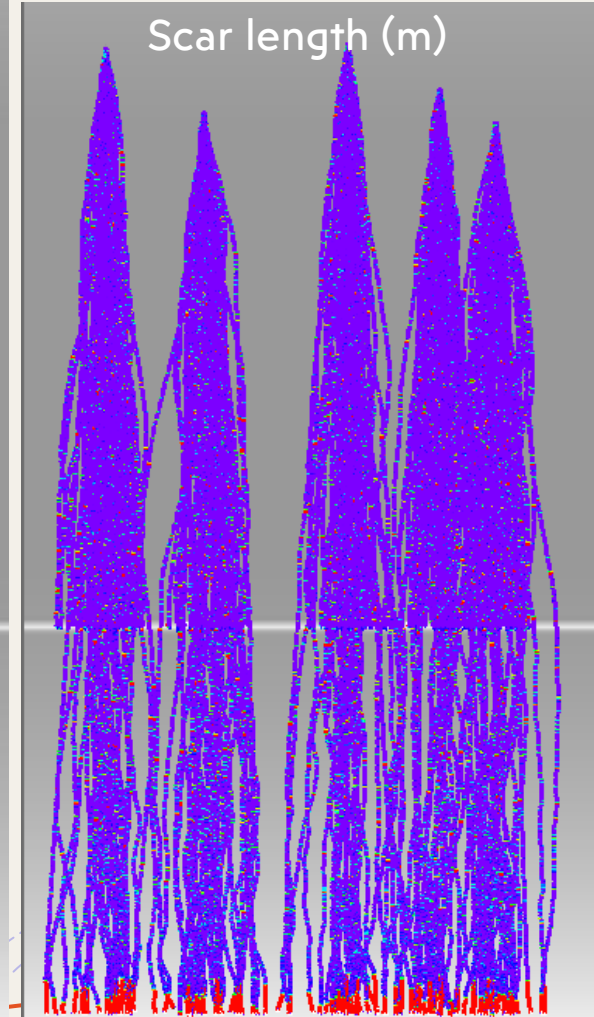
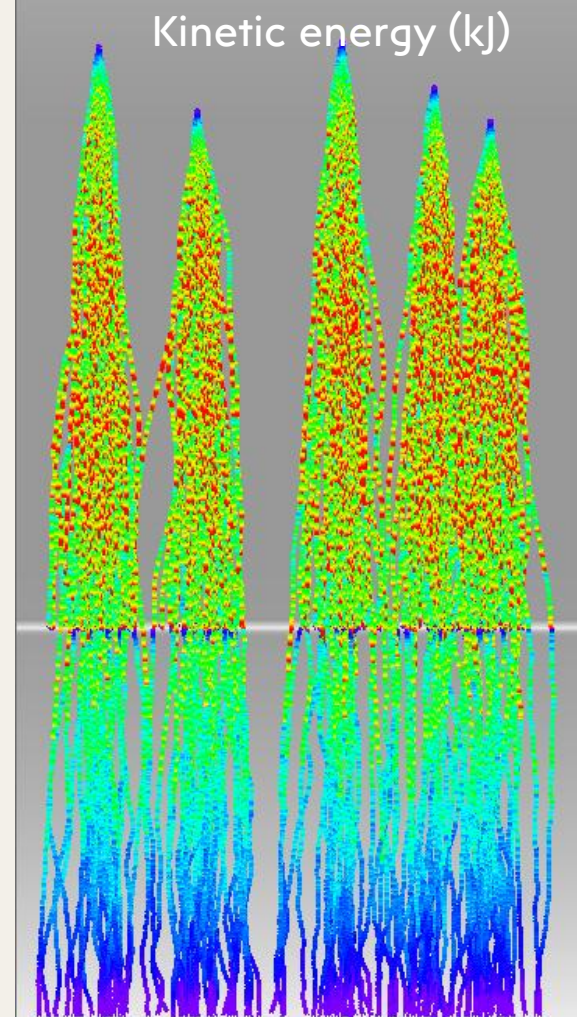
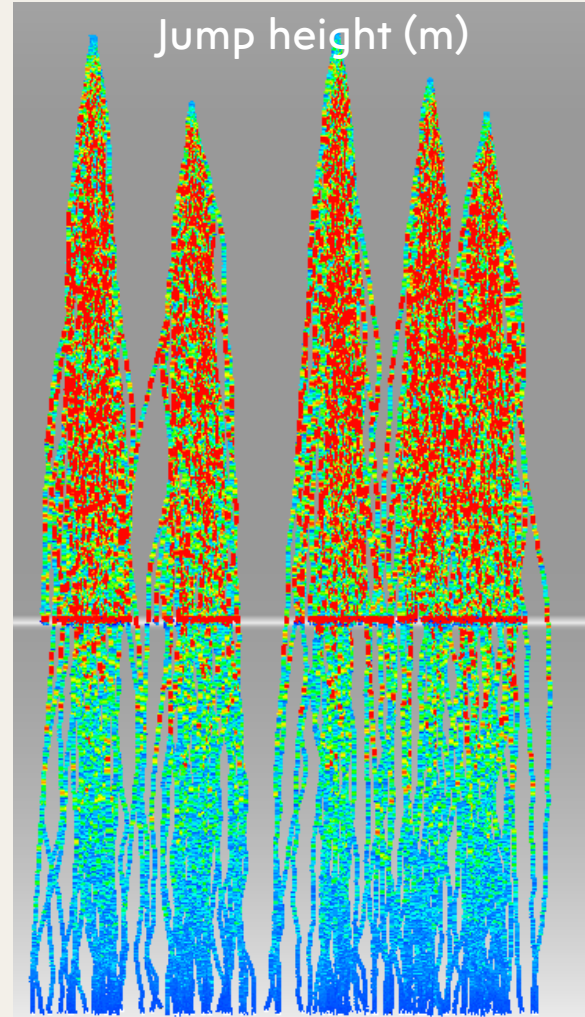
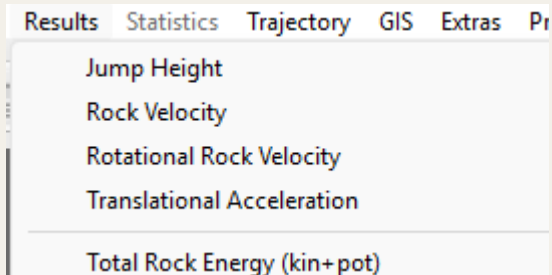


Parameters Available in Trajectory Mode

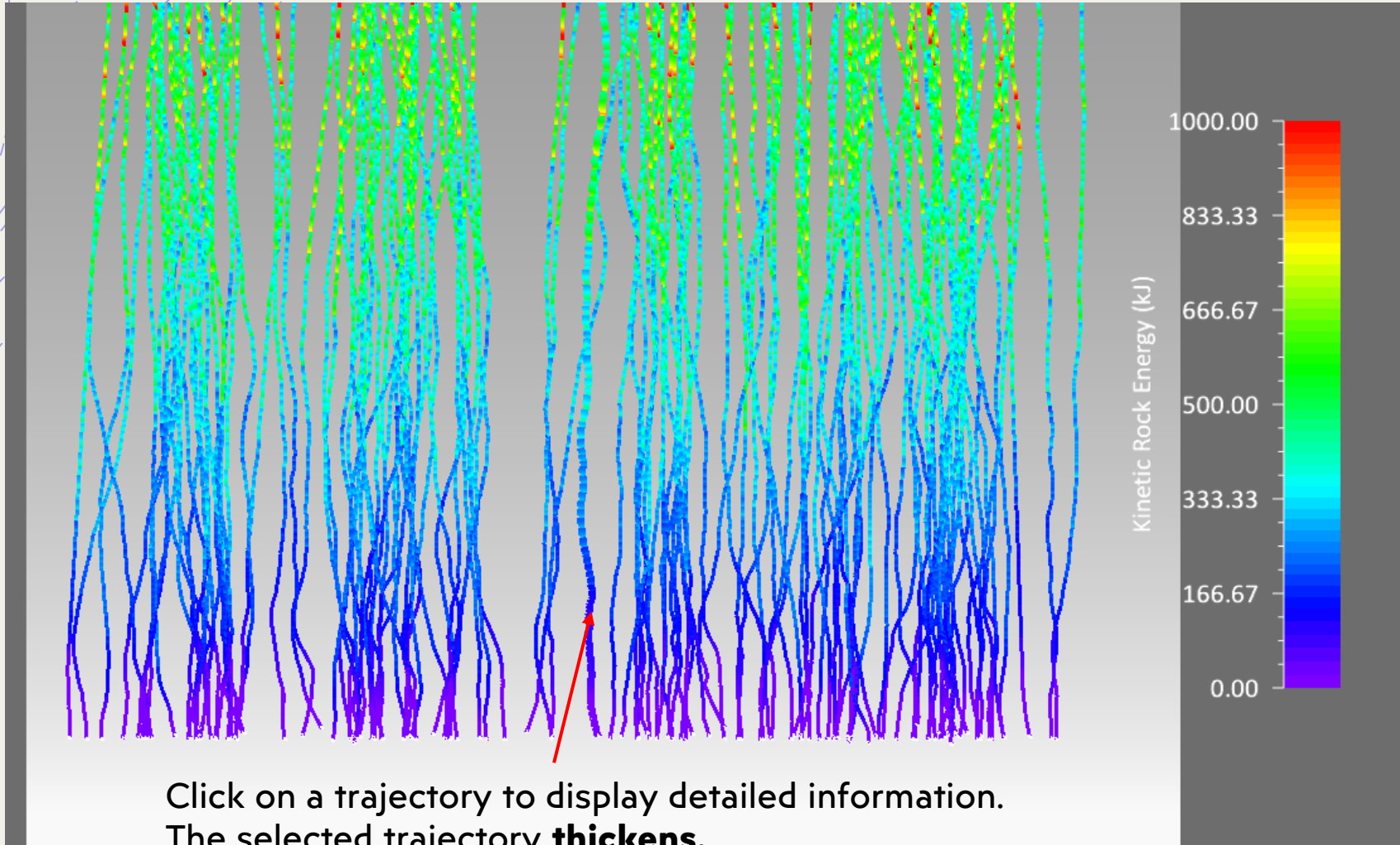


Key parameters commonly inspected in **Results dropdown menu**:

- Jump Height (m)
- Rock Velocity (m/s)
- Kinetic Rock Energy (kJ)
- Additional parameters:
- Rotational velocity
- Translational energy
- Rotational energy
- Ground drag
- Ground torque
- Scar depth
- Scar length



Working with Individual Rocks



Click on a trajectory to display detailed information.
The selected trajectory **thickens**.

Colorbar, Display & Animation Settings

Max: 1000.00 Transparency %
Min: 0.00
Colors: 50
Animation Control: FAST 25 SLOW

Various

Files General Display Rock Scenario

Scenario Information

Trajectory Information

Nr of Trajectories: 300
Trajectory-Mode: ON
Average Slope (Degrees): 40.42 / 46.57 / 47.20

Selected trajectory:
Sim_Rock_Output_Pos3_PTSEOTA_111_1.0m3_055.rts

Rock Information:

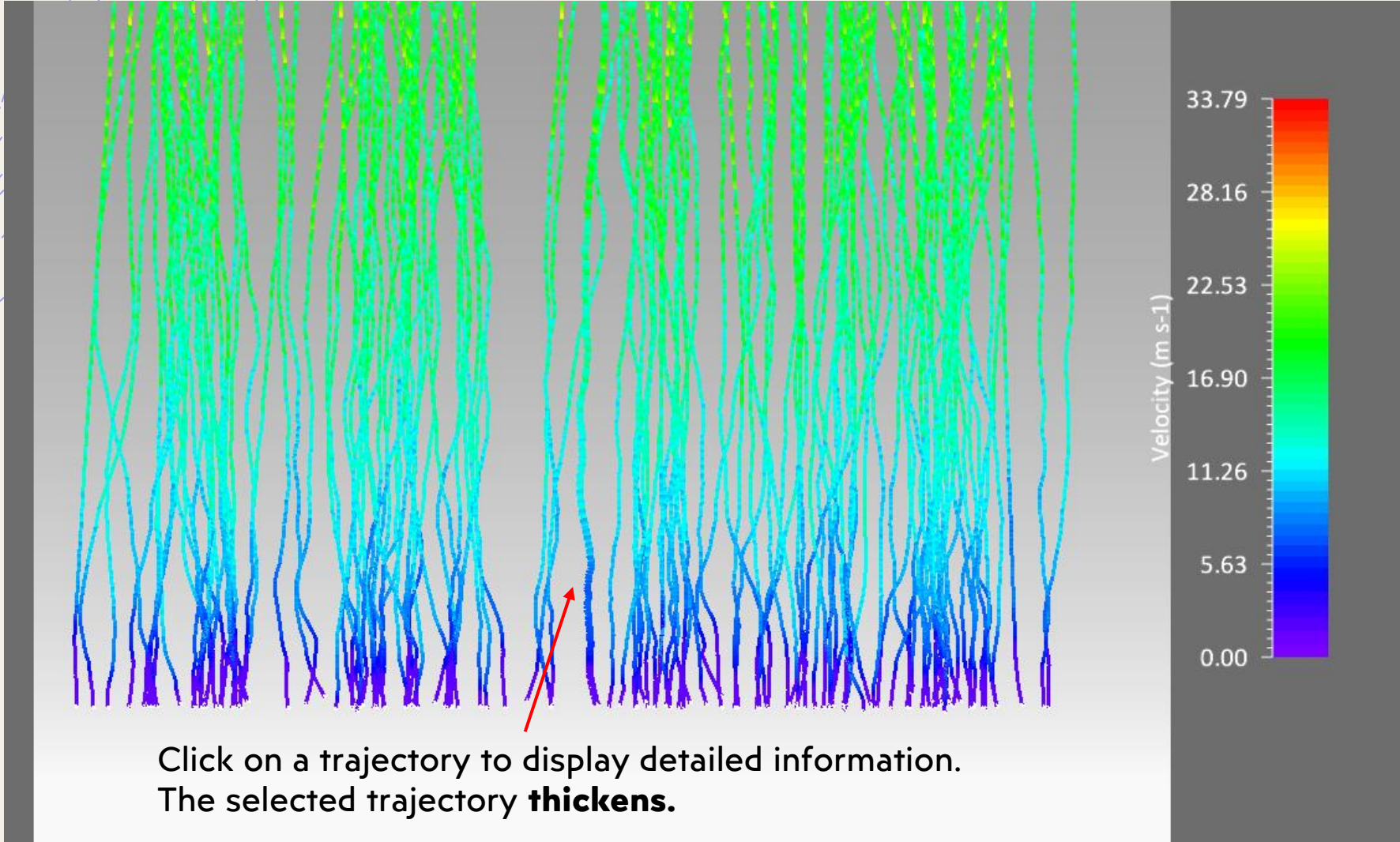
Rock Density: 2700.0 (kg/m3)
Rock Mass: 2.701 (t)
Rock Volume: 1.000 (m3)
Rock Form: EOTA_111_1.0m3.pts

Rock-Z-Offset:
Automatic Z-Offset(s)

General Tab shows:

- trajectory filename
- release location
- simulation information

Working with Individual Rocks



Click on a trajectory to display detailed information.
The selected trajectory **thickens**.

Colorbar, Display & Animation Settings

Max: [i](#) Transparency %

Min: [i](#) [i](#)

Colors: [i](#)

Animation Control: FAST SLOW [i](#)

Various

Files General Display **Rock** Scenario

Rock Information

Name: EOTA_111_1.0m3.pts

Dimensions X/Y/Z (m):

Rock Density (kg/m3):

Rock Volume (m3):

Rock Mass (kg):

- Rock Tab shows:
- rock geometry
 - block properties

Detailed Trajectory Analysis

The **Trajectory XY Plot** provides a detailed view of rock motion.

The plot shows:

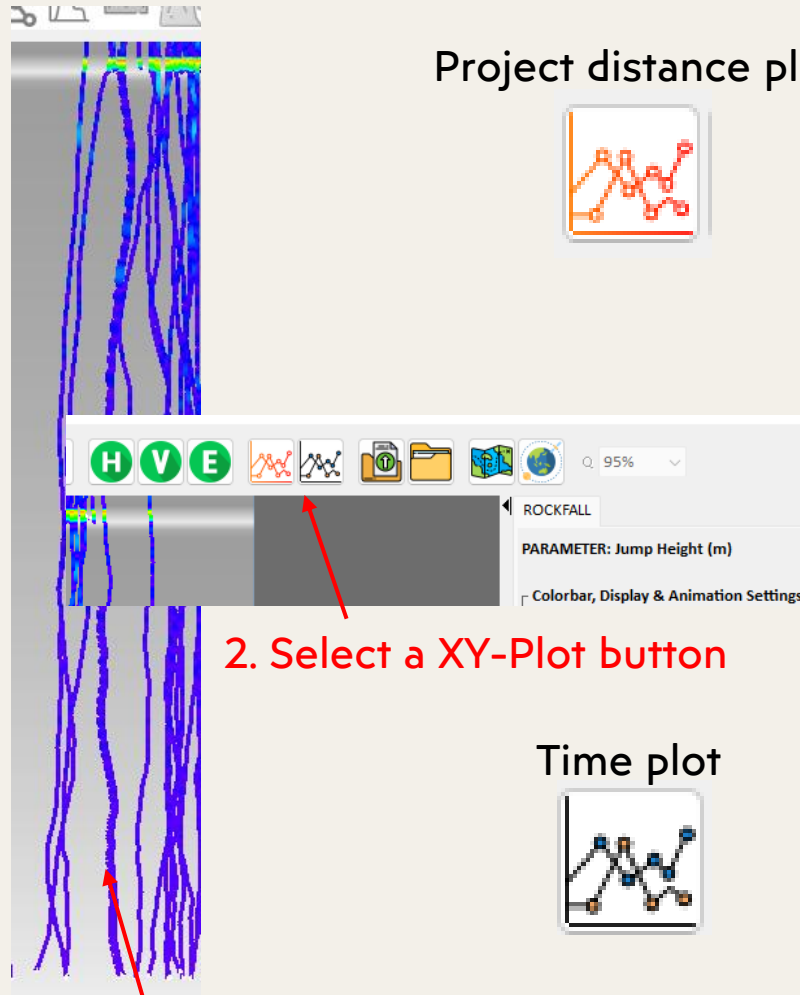
- terrain profile
- rock trajectory
- selected parameter along the path

Plot components:

- Brown line → terrain surface
- Black line → rock trajectory
- Green line → active parameter
- Red dots → impact/contact points
- Blue dot → current rock position

Engineers use this plot to understand:

- impact locations
- jump heights
- energy variations along the slope

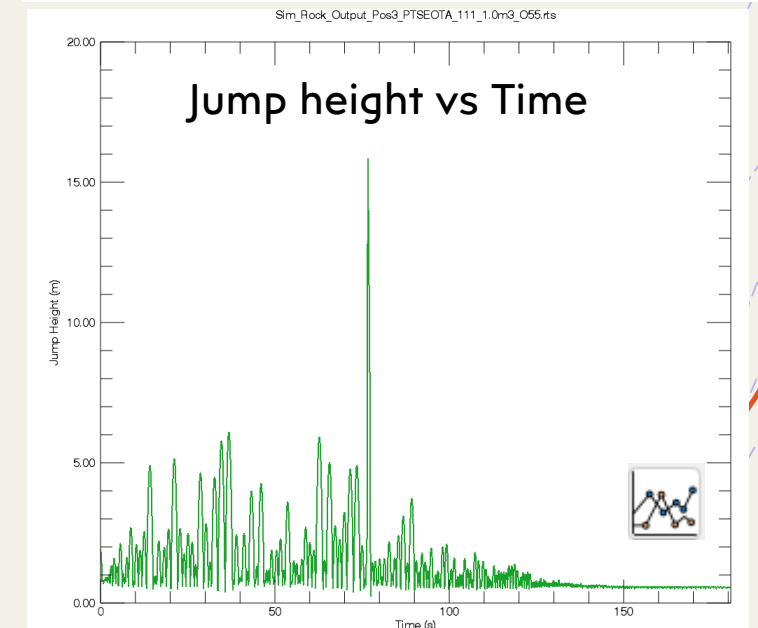
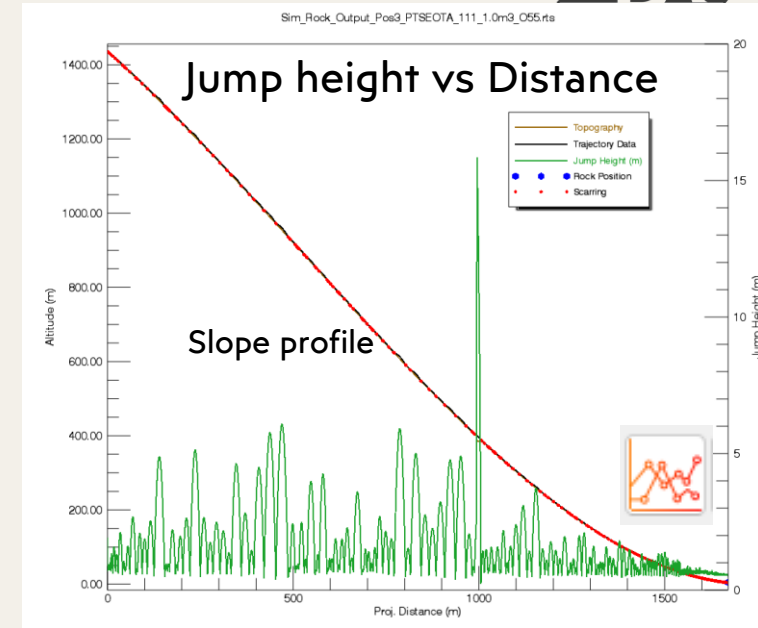
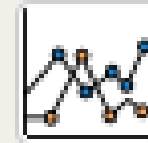


1. First select a trajectory with the mouse

Project distance plot



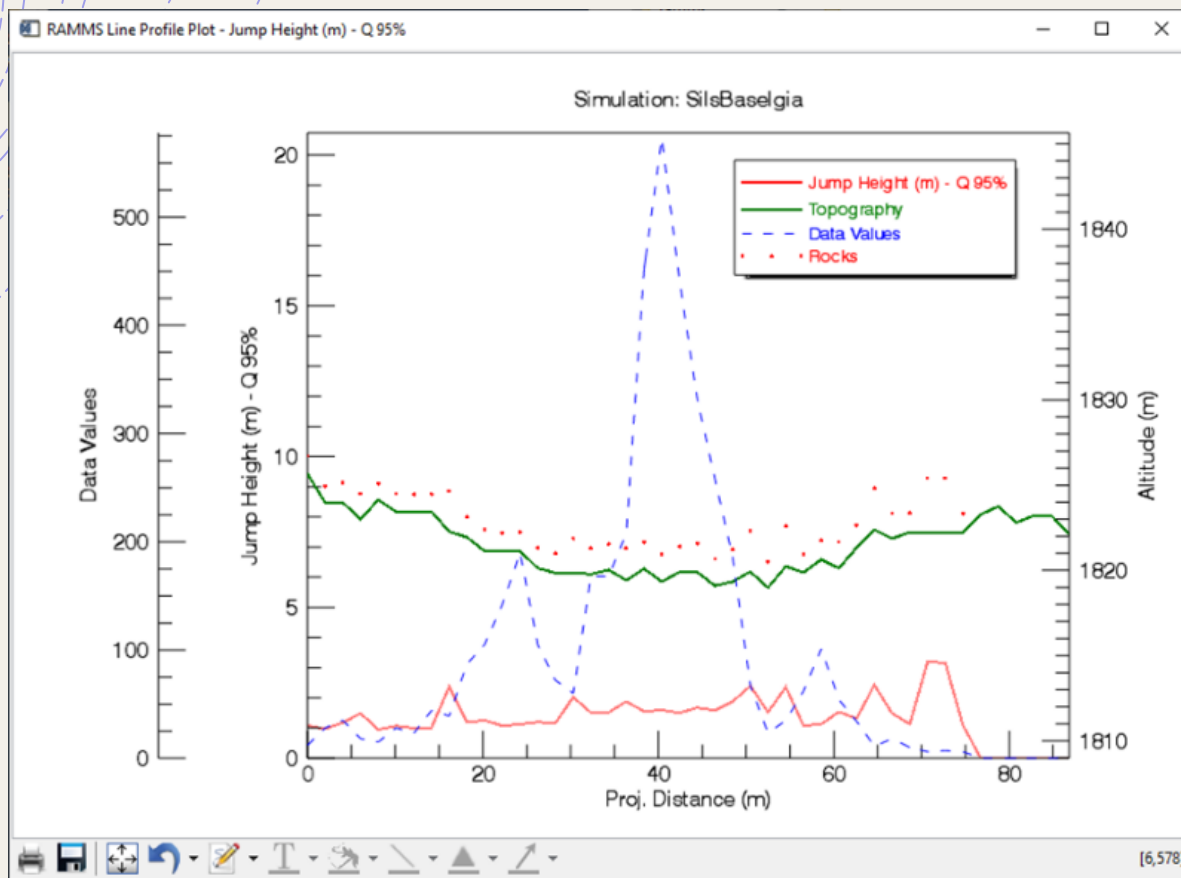
Time plot



Additional Trajectory Tools



Line Profile: Displays the selected parameter along a defined line.



Useful for analysing: roads, dams, protection lines

Trajectory > **View Trajectory Data Log File**
 Contains detailed numerical values for every simulation step.

```
Rock type: 2 (0: Sphere, 1: Cuboid, 2: Rock)
pts-file: C:\Users\...\Real_Equant_1.4.pts
Selected trajectory: C:\Users\...\Real_Equant_1.4.pts
Output file: C:\Users\...\Real_Equant_1.4.pts
Results: C:\Users\...\Real_Equant_1.4.pts
```

t (s)	x (m)	y (m)	z (m)	p0 (l)	p1 (l)	p2 (l)	f
0.000	2793296.700	1180256.300	2359.697	0.137	0.465	-	-
0.005	2793296.700	1180256.300	2359.697	0.137	0.465	-	-
0.010	2793296.700	1180256.300	2359.697	0.137	0.465	-	-
0.015	2793296.700	1180256.300	2359.697	0.137	0.465	-	-
0.020	2793296.700	1180256.300	2359.689	0.137	0.465	-	-
0.025	2793296.700	1180256.300	2359.679	0.137	0.465	-	-
0.030	2793296.700	1180256.300	2359.665	0.137	0.465	-	-
0.035	2793296.700	1180256.300	2359.647	0.137	0.465	-	-
0.040	2793296.700	1180256.300	2359.625	0.137	0.465	-	-
0.045	2793296.700	1180256.300	2359.599	0.137	0.465	-	-
0.050	2793296.700	1180256.300	2359.570	0.137	0.465	-	-
0.055	2793296.700	1180256.300	2359.536	0.137	0.465	-	-
0.060	2793296.700	1180256.300	2359.499	0.137	0.465	-	-
0.065	2793296.700	1180256.300	2359.457	0.137	0.465	-	-
0.070	2793296.700	1180256.300	2359.412	0.137	0.465	-	-
0.075	2793296.700	1180256.300	2359.363	0.137	0.465	-	-
0.080	2793296.700	1180256.300	2359.310	0.137	0.465	-	-
0.085	2793296.700	1180256.300	2359.253	0.137	0.465	-	-
0.090	2793296.700	1180256.300	2359.192	0.137	0.465	-	-
0.095	2793296.700	1180256.300	2359.127	0.137	0.465	-	-
0.100	2793296.700	1180256.300	2359.058	0.137	0.465	-	-
0.105	2793296.700	1180256.300	2358.985	0.137	0.465	-	-
0.110	2793296.700	1180256.300	2358.908	0.137	0.465	-	-
0.115	2793296.700	1180256.300	2358.828	0.137	0.465	-	-
0.120	2793296.700	1180256.300	2358.743	0.137	0.465	-	-
0.125	2793296.700	1180256.300	2358.655	0.137	0.465	-	-
0.130	2793296.700	1180256.300	2358.562	0.137	0.465	-	-
0.135	2793296.700	1180256.300	2358.466	0.137	0.465	-	-
0.140	2793296.700	1180256.300	2358.366	0.137	0.465	-	-
0.145	2793296.700	1180256.300	2358.261	0.137	0.465	-	-
0.150	2793296.700	1180256.300	2358.153	0.137	0.465	-	-
0.155	2793296.700	1180256.300	2358.041	0.137	0.465	-	-
0.160	2793296.700	1180256.300	2357.925	0.137	0.465	-	-
0.165	2793296.700	1180256.300	2357.827	0.116	0.467	-	-
0.170	2793296.700	1180256.300	2357.750	0.071	0.472	-	-

Trajectory Animation: Allows visualization of rock motion in time.

- Start animation
- Pause animation (F8)
- Stop/Restart animation (F9)



Animation Control: FAST 25 SLOW ⓘ

Frames per second: use slider to change animation speed

Adjust animation speed

Summary



- 1. Statistics Mode converts thousands of trajectories into engineering hazard maps.** Results are evaluated **per raster cell** to produce representative values such as **Q95 kinetic energy, jump height and reach probability**.
- 2. Each raster cell stores the full distribution of trajectory impacts.** Statistics such as **mean, quantiles and maximum values** are derived from the set of trajectories passing through that cell.
- 3. Distribution plots help evaluate reliability of results.** Histograms, PDF/CDF, and boxplots reveal **skewness, variability and extreme events**, helping assess whether high quantiles are meaningful.
- 4. Trajectory Mode explains the physics behind the statistics.** By inspecting individual trajectories, engineers can **verify extreme events, analyze rock motion, and understand impacts on structures**.