



RockaVELA & rockfall frequency

Frédéric Berger & Luuk Dorren

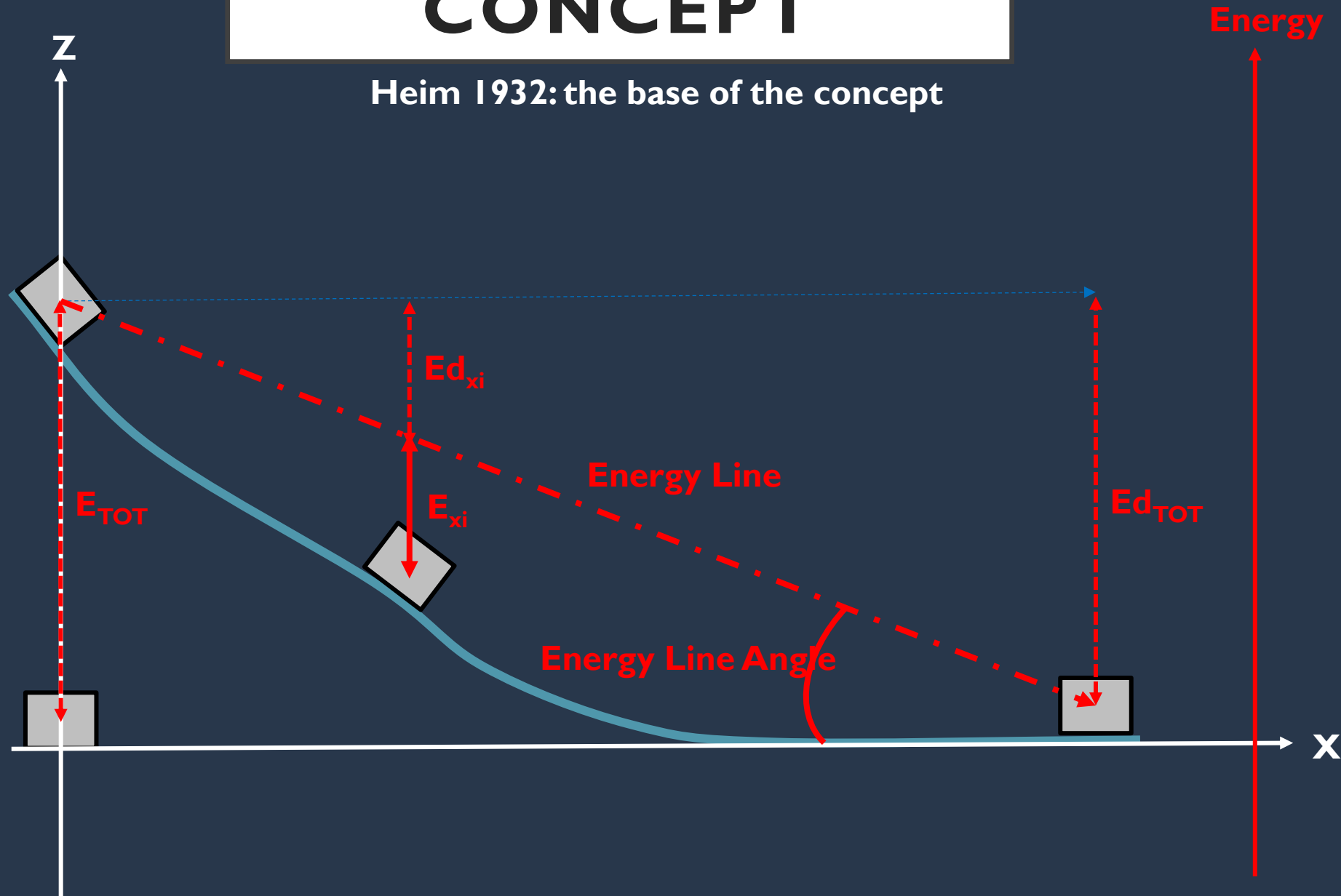
ecorisQ GA, 2 May 2023 Bolzano

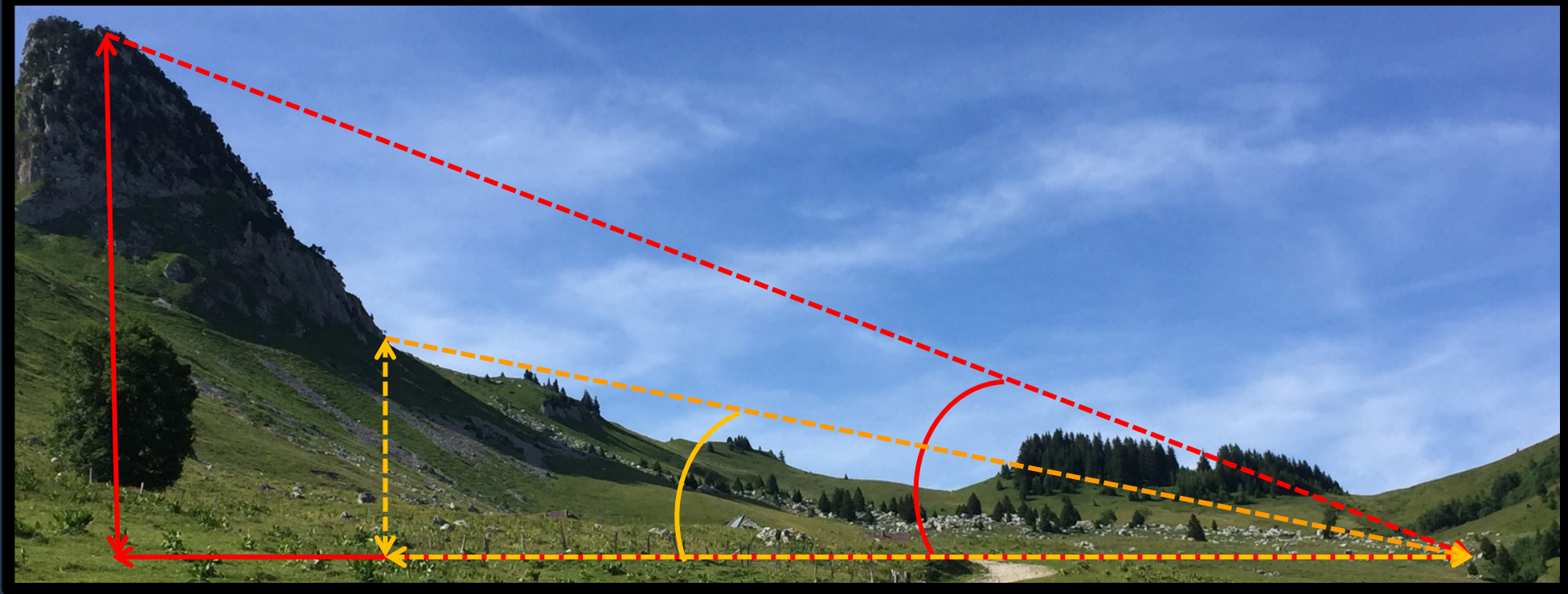
With contributions of: Zeno Bontognali, Franck Bourrier,
Didier Hantz, Michel Jaboyedoff, Christine Moos, David Toe

ROCKAVELA

THE ENERGY LINE CONCEPT

Heim 1932: the base of the concept

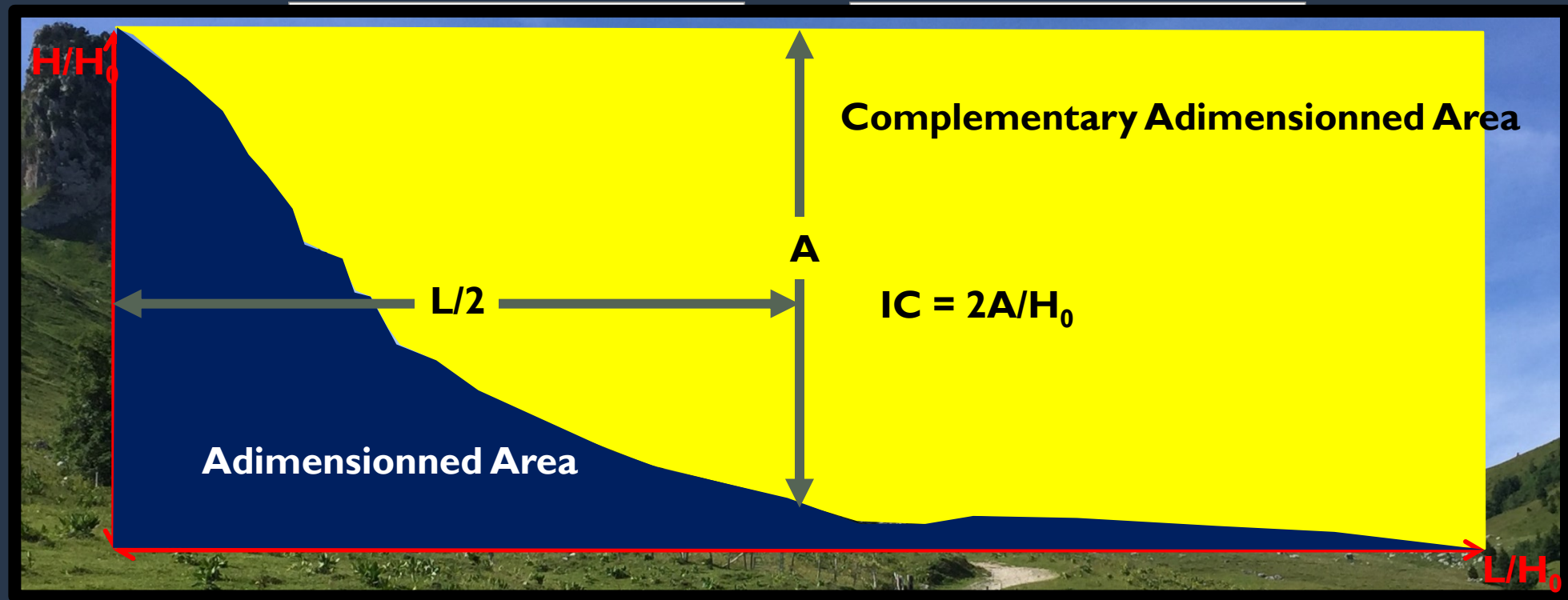




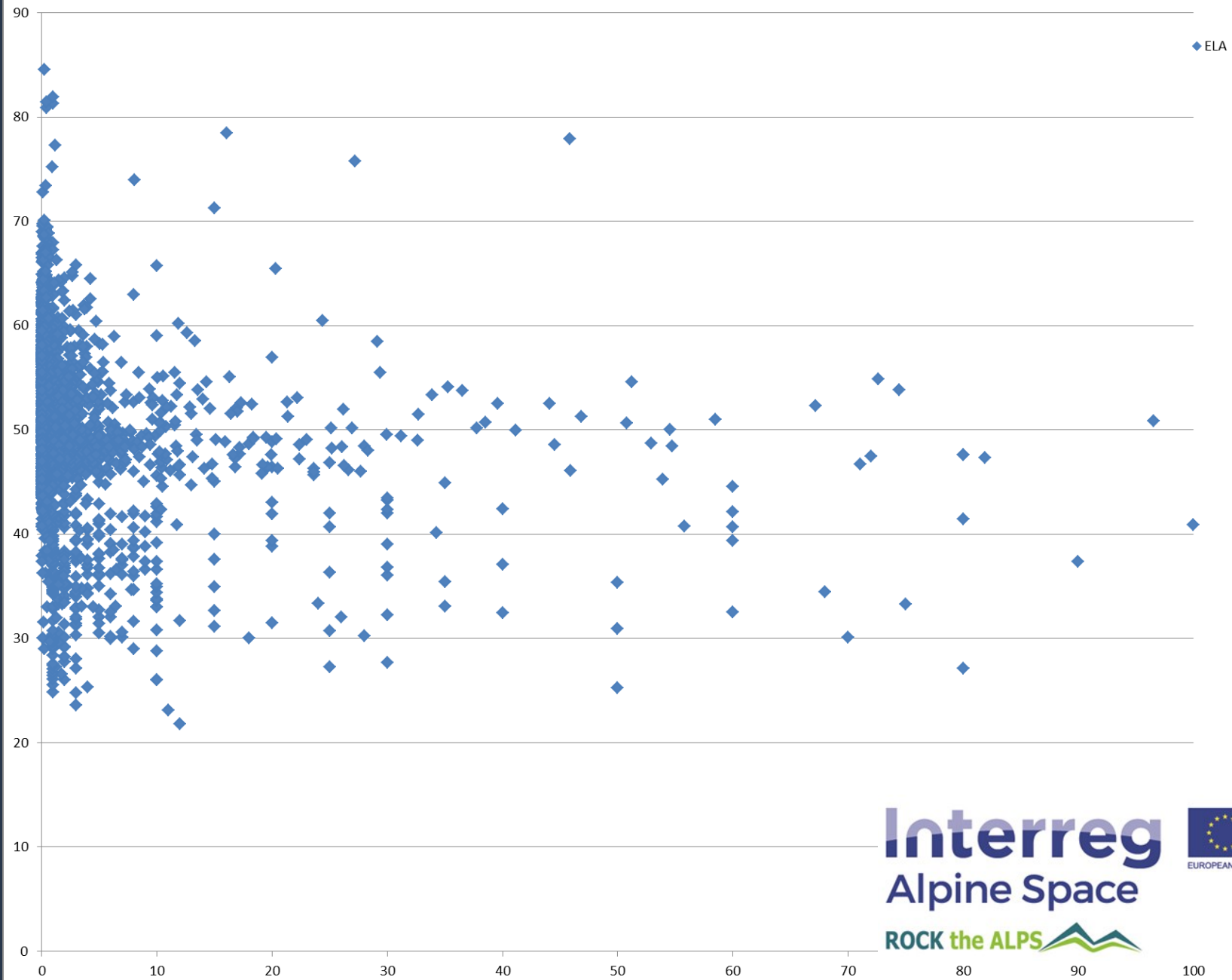
Source / Auteur	Valeur angle d'énergie (géométrique)
Shreve (1968)	26,57° - 38,66°
Hsü (1975)	32°
Onofri & Candian (1979)	28,84 ° - 41,73°
Grunder (1984)	33,1° - 34,4°
Moser (1986)	34° - 43°
Domaas (1985 in Toppe 1987)	33°
Mac ewen (1989)	30,96°
Gerber (1994)	33,5° - 38°
Meissl (1998)	29,5° - 48,5°
Heinimann et al. (1998)	33,5° - 38°
Focardi & lotti (2001)	27,5° - 30°
Ayala-carcedo et al. (2001)	29,1° - 38,9°
Jaboyedoff & Labouise (2003)	33°
Jaboyedoff & Labouise (2011)	32,6° - 35,6°
Corominas et al. (2003)	27° - 55°
Dorren & Berger (2005, 2006)	31,9° - 38 °
Scheidegger (1973)	29,68° - 39,69°
Deparis et al (2008)	31,61° - 47,20°
Hyndman & Hyndman (2009)	33°
Berger et al. (2009)	27,67° - 33,88°
Base de données RTM (données 2011-2013)	24,65° - 58,42°

Hungr O (in memoriam)

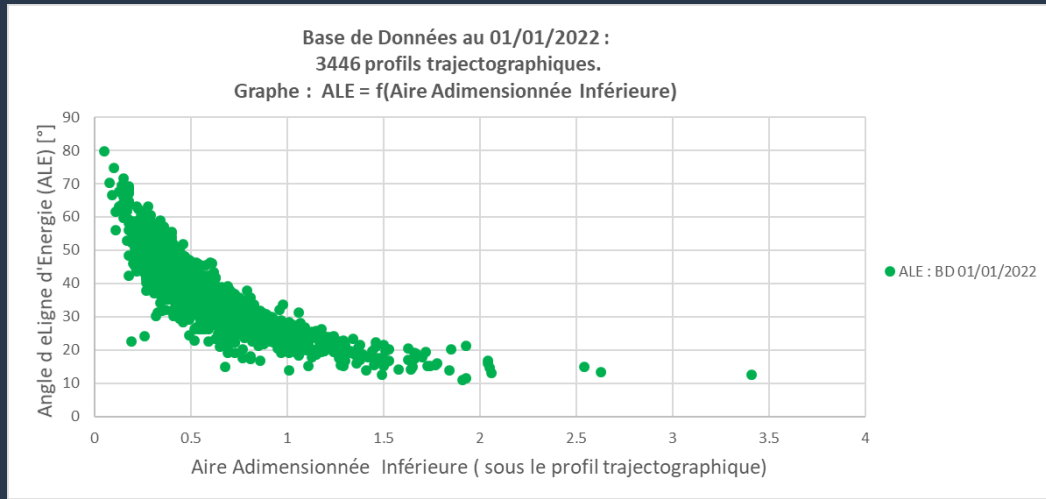
Classical approach for ELA but...



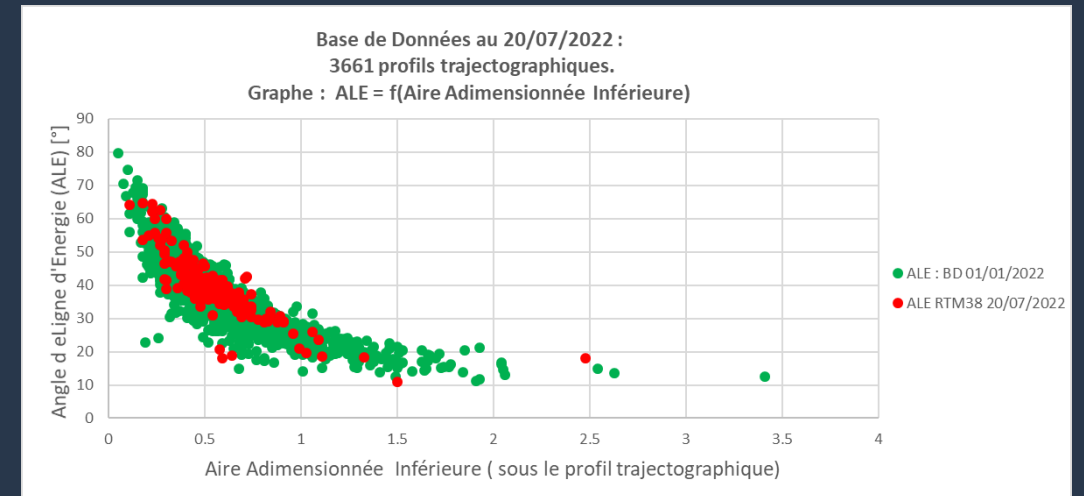
Vol vs ALE



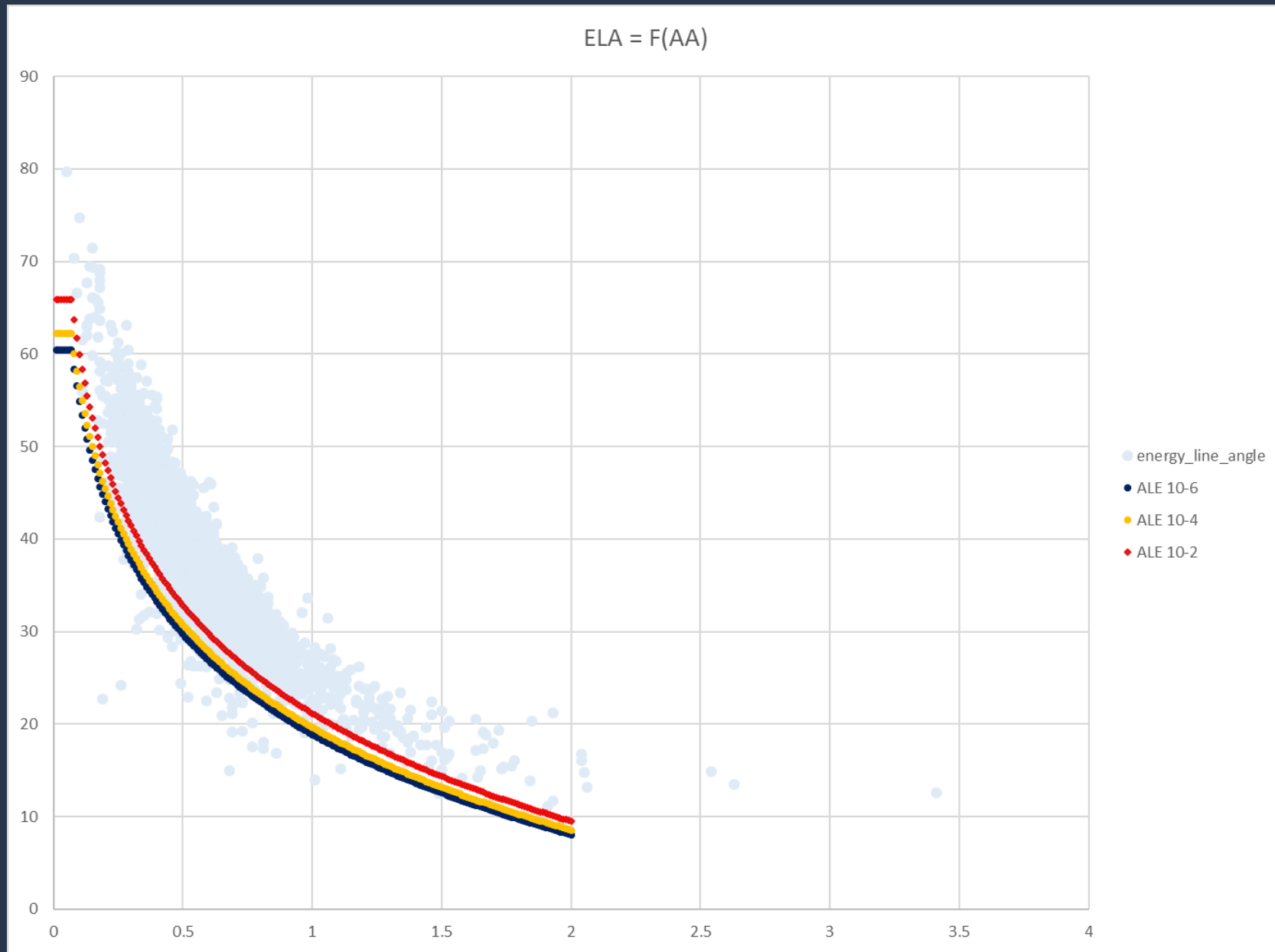
The observed field/range of possibilities



Data mining



Statistical analysis : ELA probability of occurrence by Adimensionned area interval of 0,01





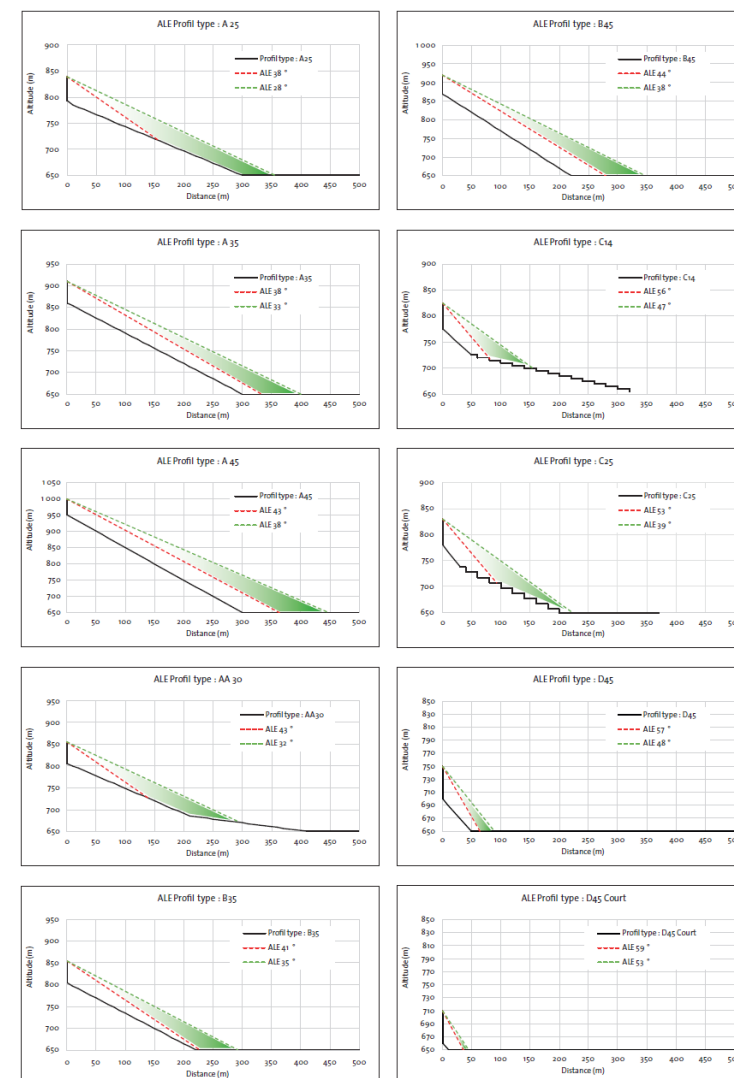
Guide technique

Aléa rocheux

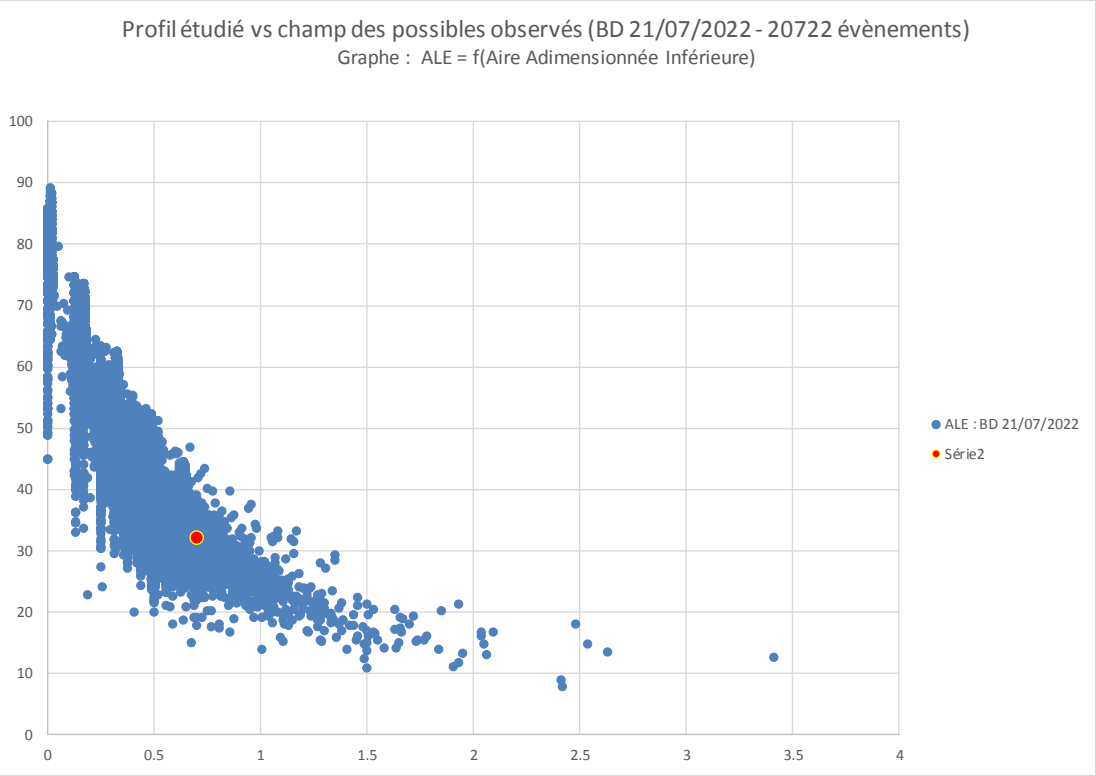
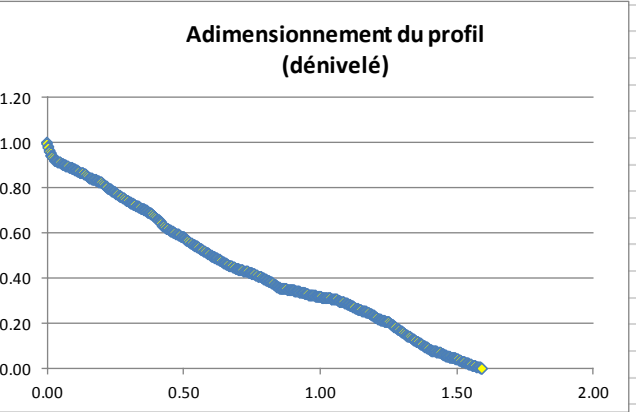
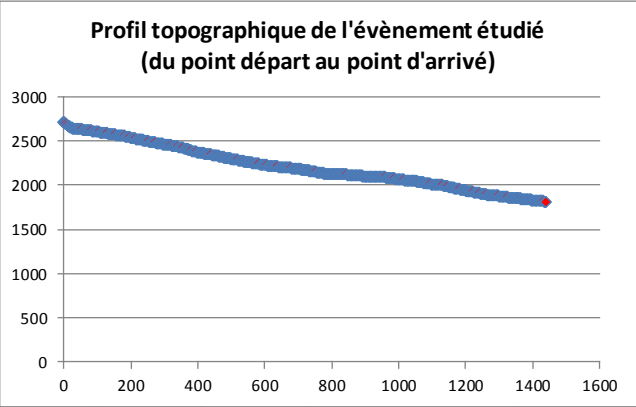
Note méthodologique « MEZAP »
Caractérisation de l'aléa rocheux
dans le cadre d'un Plan de Prévention
des Risques Naturels (PPRn)
ou d'un Porter à connaissance (PAC)



illustration 3.11 – Représentation graphique des emprises de propagation maximales probables pour les différentes configurations topographiques types retenues avec les résultats présentés illustration 3.9



ID	X	Z	Max Z	Min Z	Δ Z	Planimetric distance	ELA	RESULATS	
0	0	2718.53369	2718.533691	1816.263306	902.27	1439.66	32.08	AAInf	ALE
1	2.31085611	2714.37866						0.70	32.08
2	4.62171222	2703.65991							
3	6.93256834	2696.55737							
4	9.24342445	2687.87695							
5	11.5542806	2683.38354							
6	13.8651367	2673.98267							
7	16.1759928	2667.06885							
8	18.4868489	2664.11157							
9	20.797705	2657.88525							
10	23.1085611	2653.95093							
11	25.4194172	2646.92065							
12	27.7302733	2643.76147							
13	30.0411295	2643.1333							
14	32.3519856	2642.3313							
15	34.6628417	2641.96509							
16	36.9736978	2640.59009							
17	39.2845539	2639.96069							
18	41.59541	2638.13818							
19	43.9062661	2636.98584							
20	46.2171222	2636.4585							
21	48.5279784	2634.68823							
22	50.8388345	2633.99512							
23	53.1496906	2631.89355							
24	55.4605467	2630.6438							
25	57.7714028	2628.8584							
26	60.0822589	2627.07251							
27	62.393115	2626.3418							
28	64.7039711	2624.59473							
29	67.0148273	2623.40894							
30	69.3256834	2622.00806							
31	71.6365395	2620.8269							
32	73.9473956	2619.87231							
33	76.2582517	2618.70728							
34	78.5691078	2617.81665							
35	80.8799639	2616.83545							
36	83.19082	2615.8208							



Output directory

Input DEM file

Start cells file

Simulation settings

Number of simulations

Segment length (m)

Profile step (m)

Max deviation angle (°)

Initial fall height (m)

Propagation probability

☐ Save trajectory points



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Output directory

Input DEM file

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Simulation settings

Number of simulations

Segment length (m)

Profile step (m)

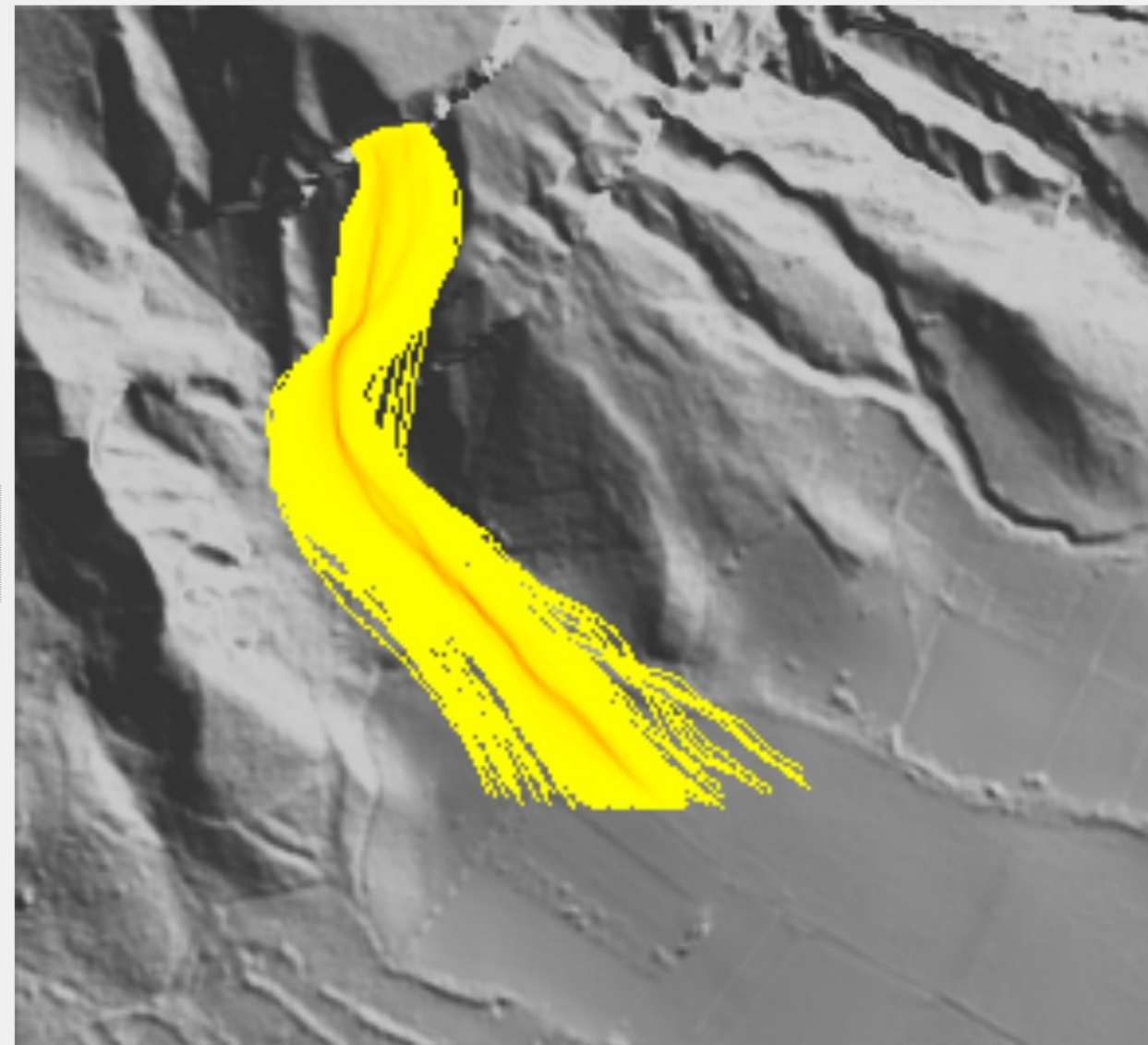
Max deviation angle (°)

Initial fall height (m)

Propagation probability

☐ Save trajectory points

Starting processing...
Results written to folder C:/Users/frederic.berger/1000sims_10deg_2m_2023-04-28T153914
Done.



Reach probability map

Output directory

Input DEM file

Start cells file

Simulation settings

Number of simulations

Segment length (m)

Profile step (m)

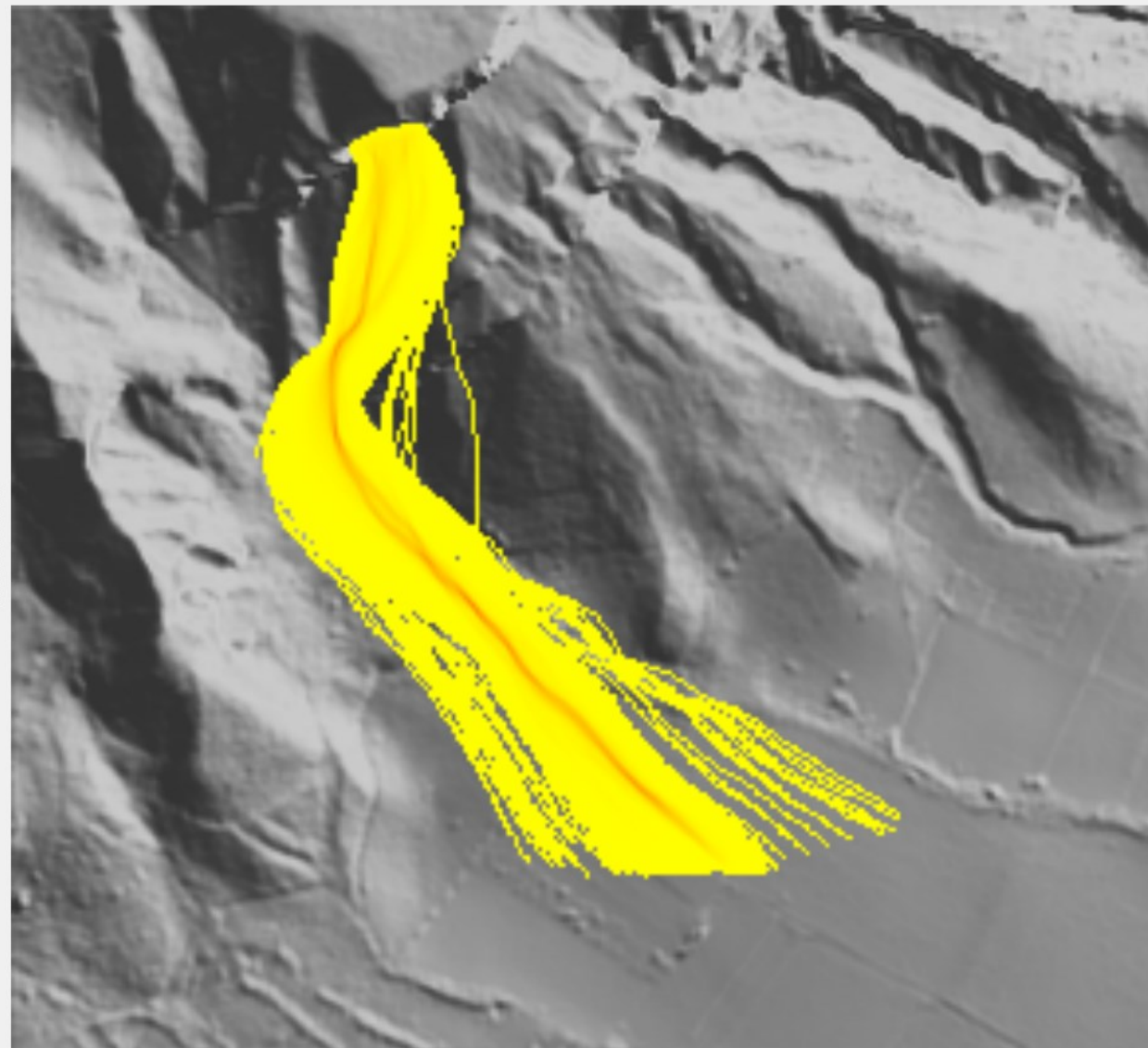
Max deviation angle (°)

Initial fall height (m)

Propagation probability

☐ Save trajectory points

Starting processing...
Results written to folder C:/Users/frederic.berger/1000sims_10deg_2m_2023-04-28T153506
Done.



Reach probability map

Output directory

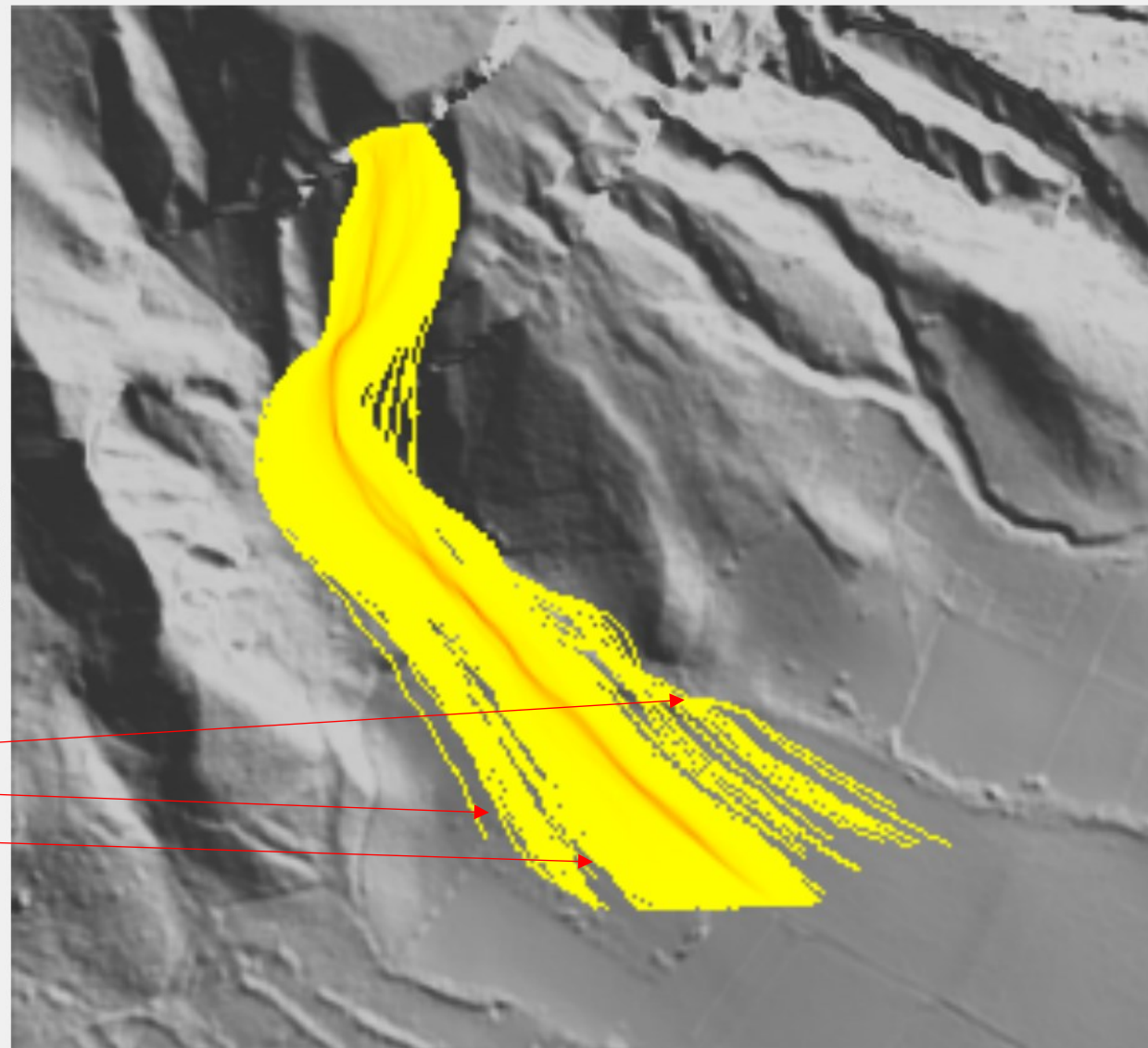
Input DEM file

Start cells file

Simulation settings

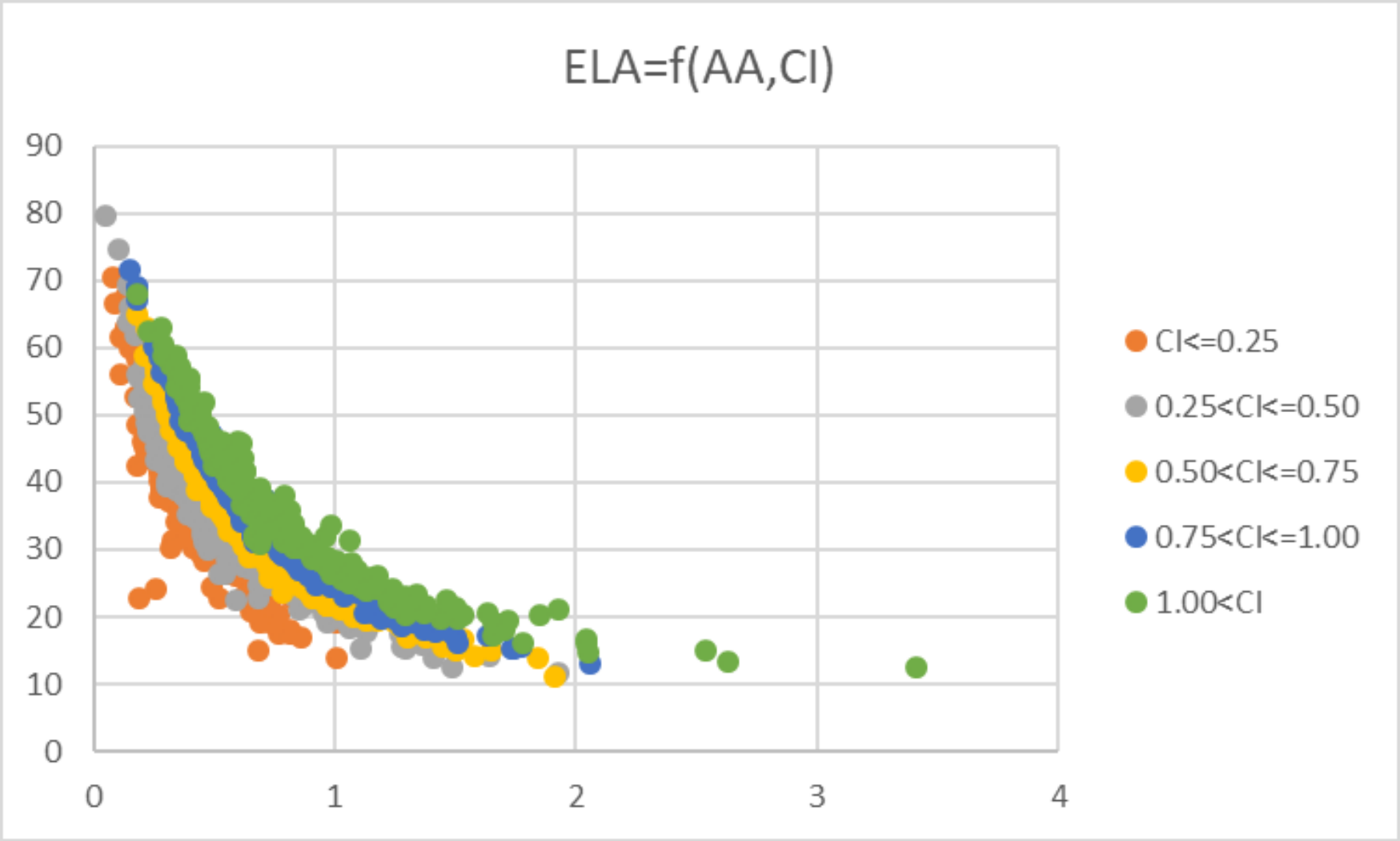
Number of
Segment
Profile step
Max deviation
Initial fall
Propagation
☐ Save to

Starting point
Results written
Done.

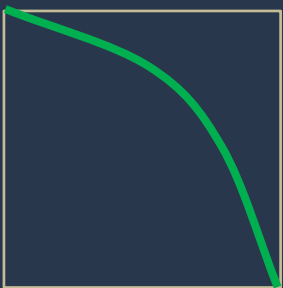


Reach probability map

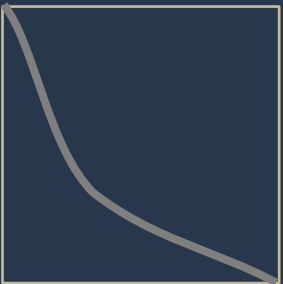
Effect of the convexity : to be analyzed



CI > 1

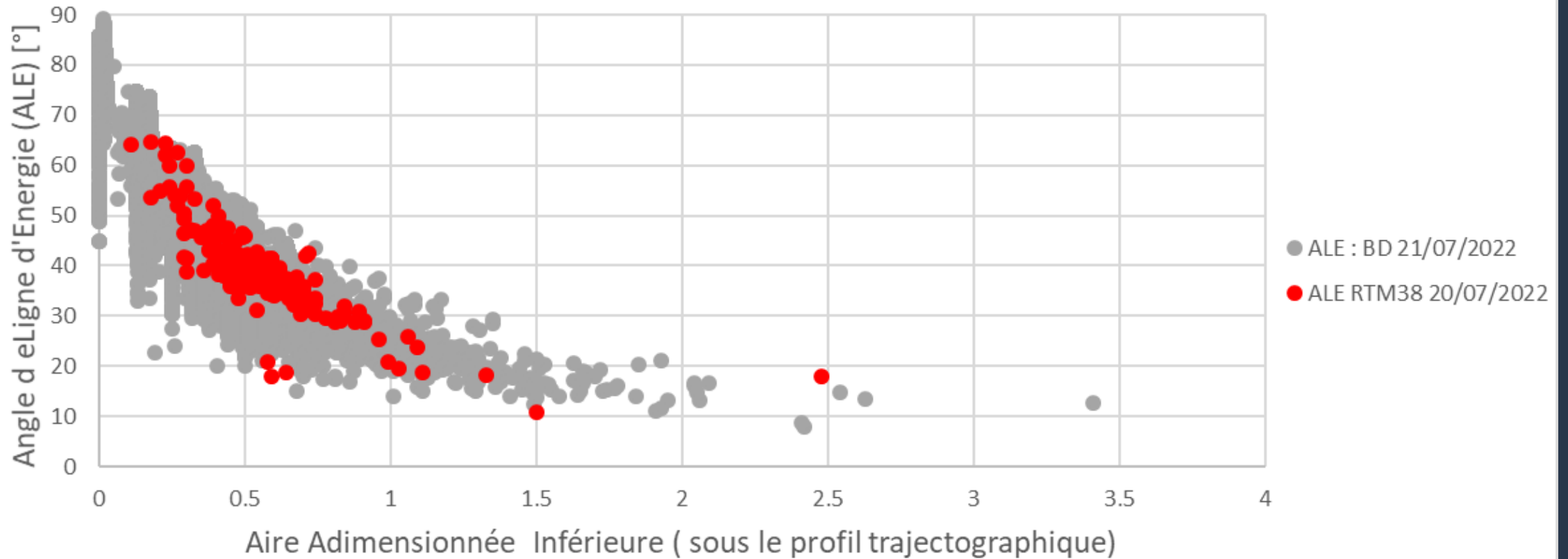


CI = 1

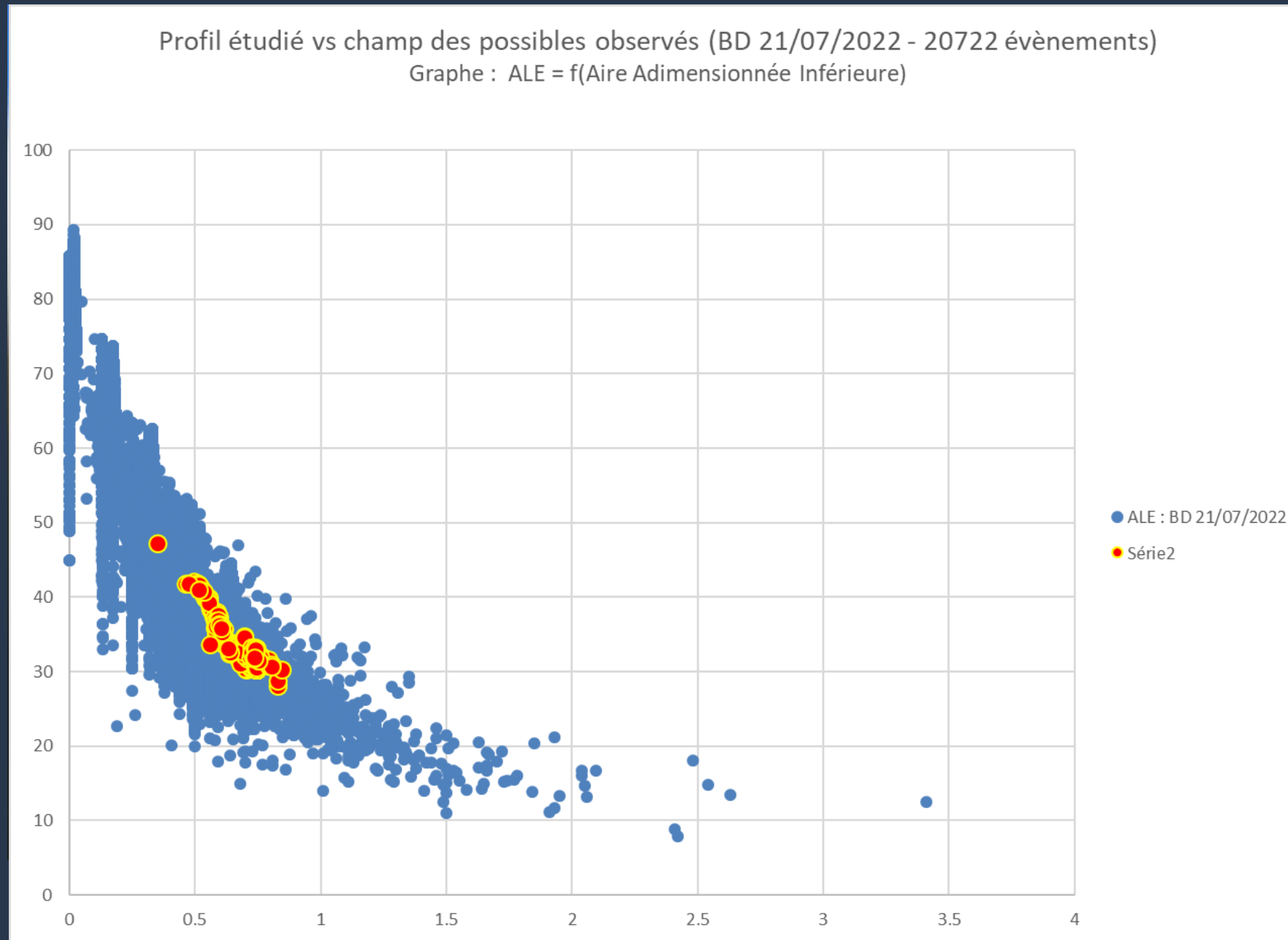


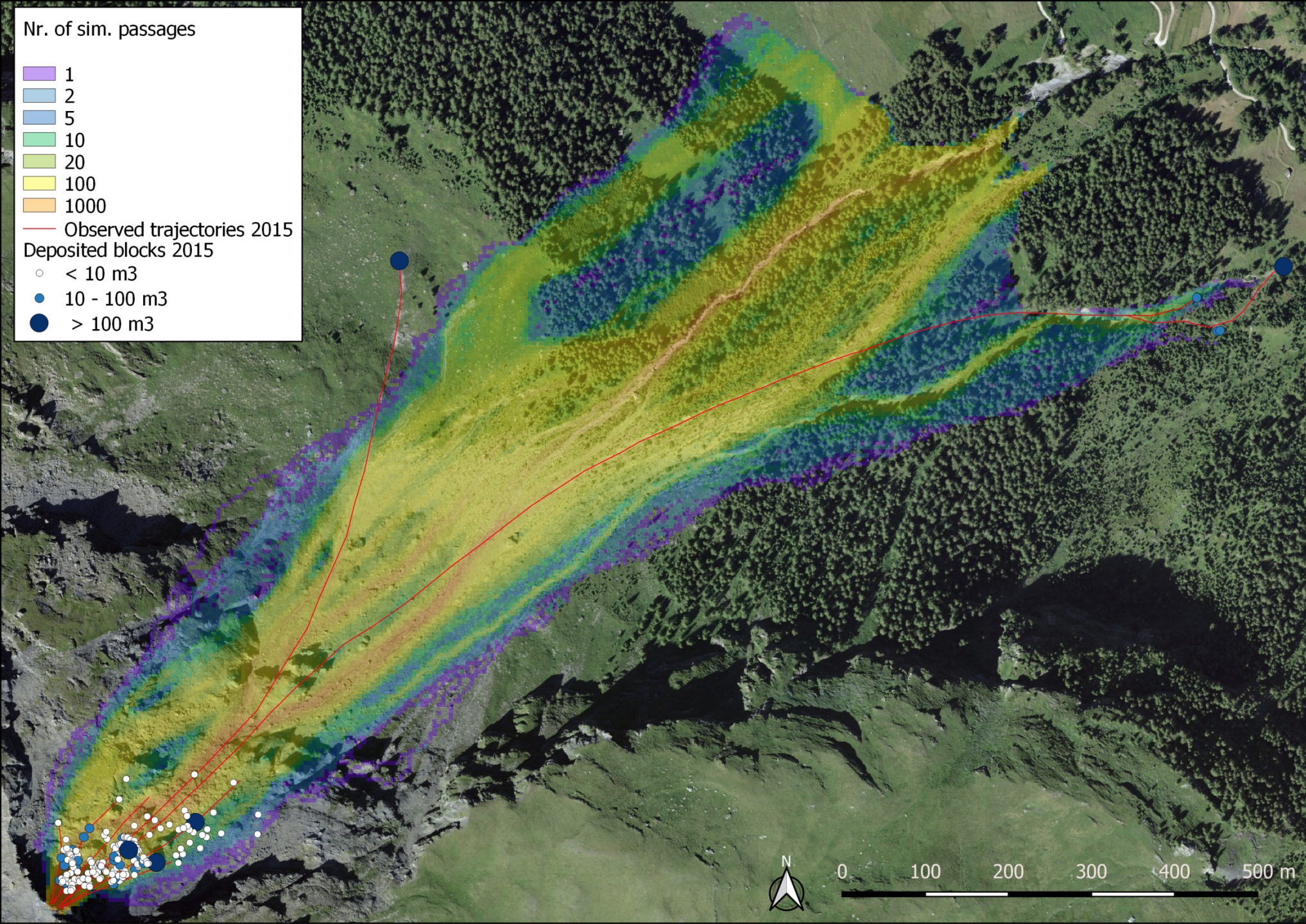
To improve the data base : « new past » events data mining

Base de Données au 21/07/2022 :
20722 profils trajectographiques.
Graphe : ALE = f(Aire Adimensionnée Inférieure)

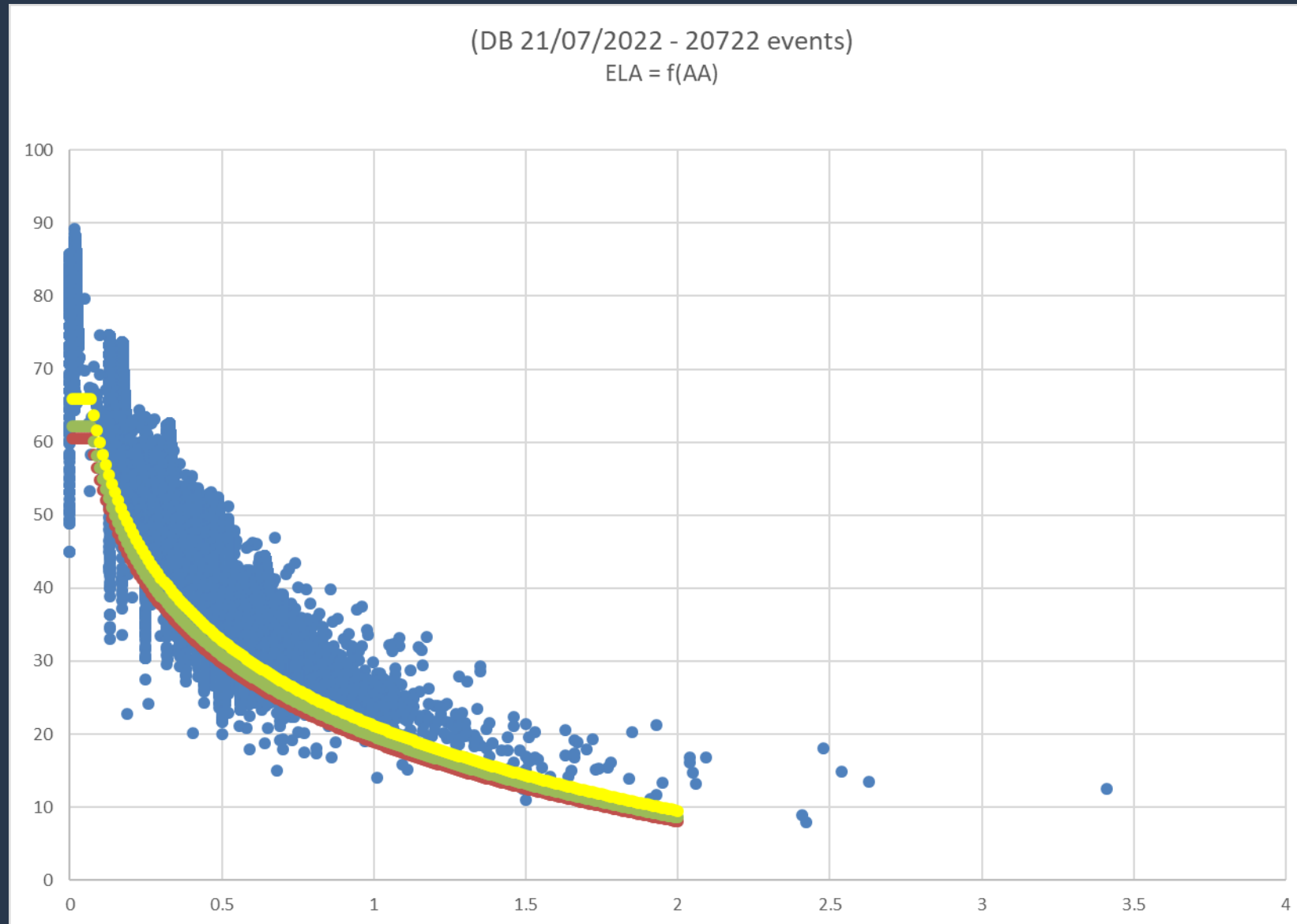


To improve the data base : data mining – Mel de la Niva CH





To calibrate the statistical laws





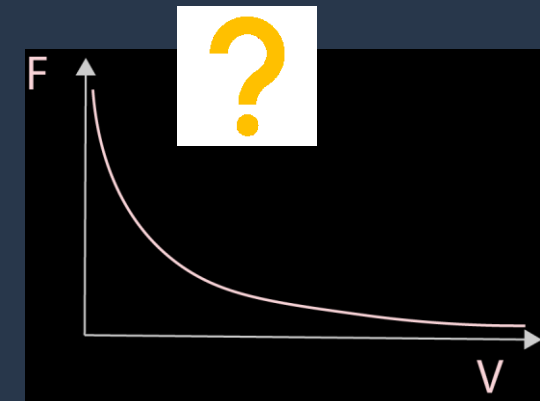
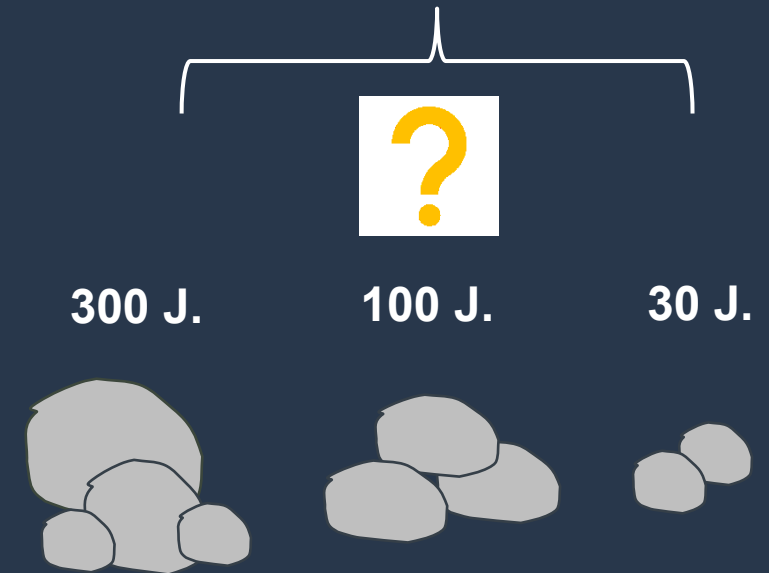
frederic.berger@inrae.fr

- Date of the event, country, contact person
- Damages?
- Release point : volume total, X,Y, Z
- Runout point(s) : at minima the maximal one
 - Volume of the boulder, X,Y, Z (for each boulders)
- The profile : at minima direct line between the release point and each runout points surveyed
 - Info of the DTM and the resolution used : 1, 2, 2.5, 5, 10 m?
 - Excel file in CSV (1 for each profile) : ID, X,Y , Z

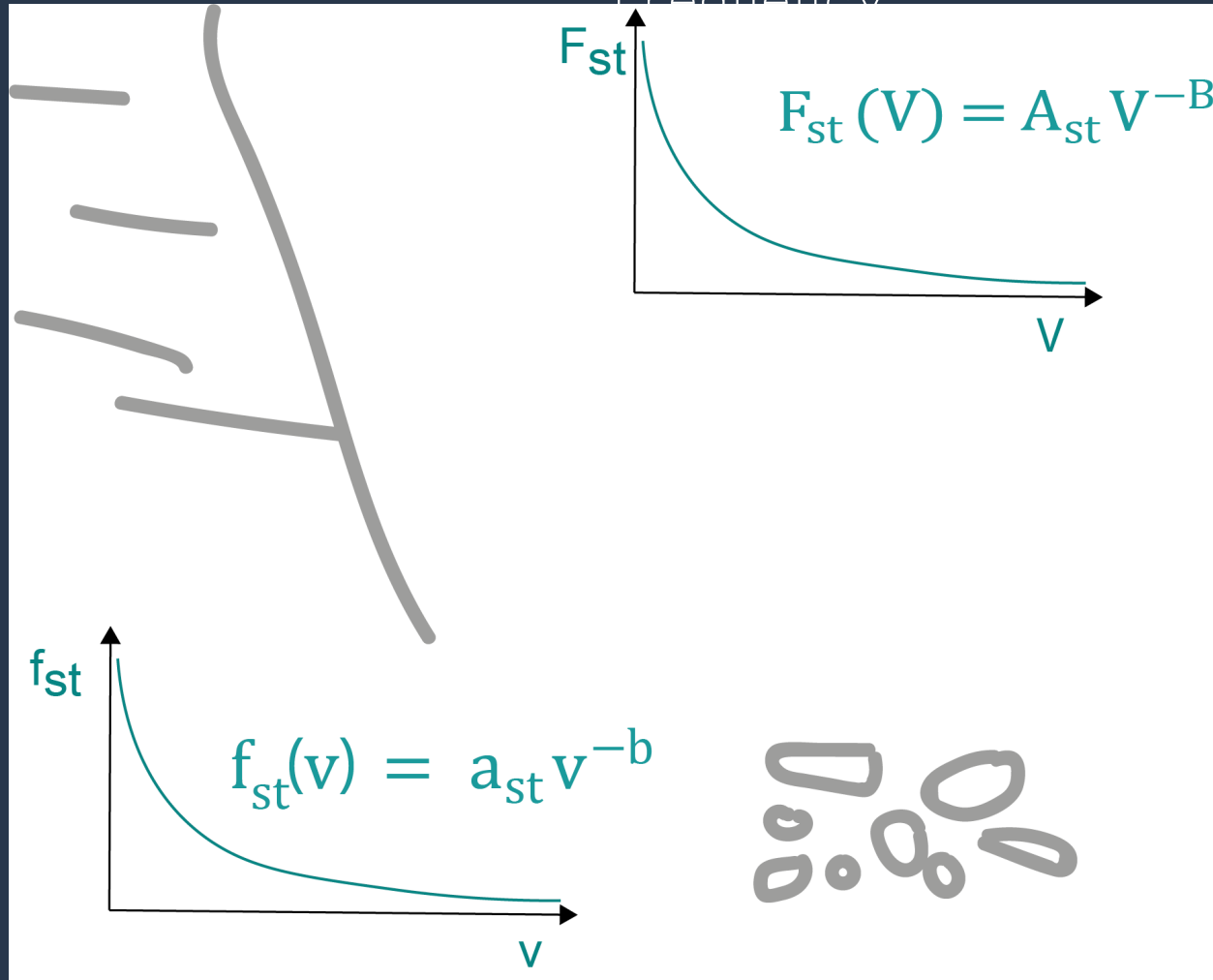
ROCKFALL FREQUENCY TOOL

Background

- Lacking data
- Rockfall scenarios often subjective
- «decoupling» Event-Blockvolumes and frequencies



st: spatio-temporal
frequency



Rock mass fall

event



Power-Law-
Distribution



Individual
blocks

Moos et al., 2022: *Estimating rockfall and block volume scenarios based on a straightforward rockfall frequency model.* Engineering

Scenario calculation

1) Parameter estimation

A_{st} [yr ⁻¹ ha ⁻¹]	0.1
B	0.8
S [ha]	1.7
V_{max} [m ³]	50
b	1.05

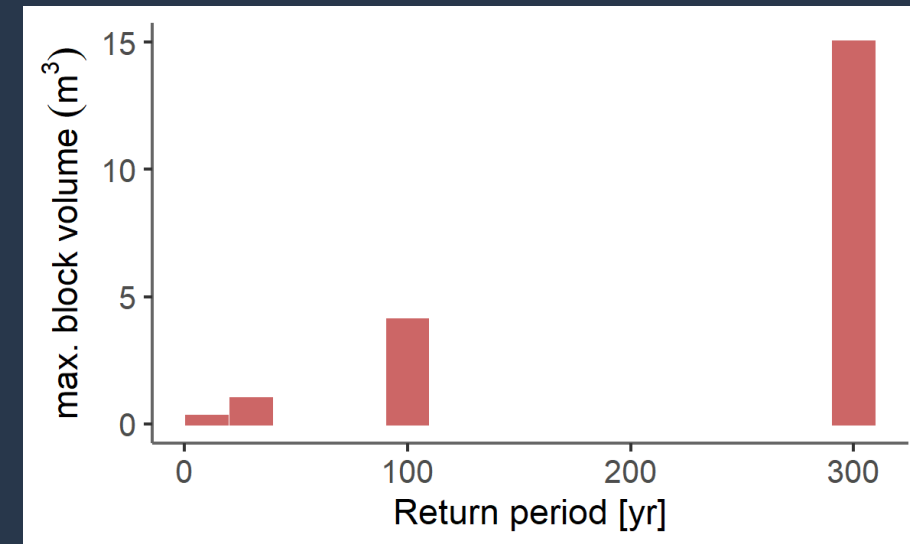
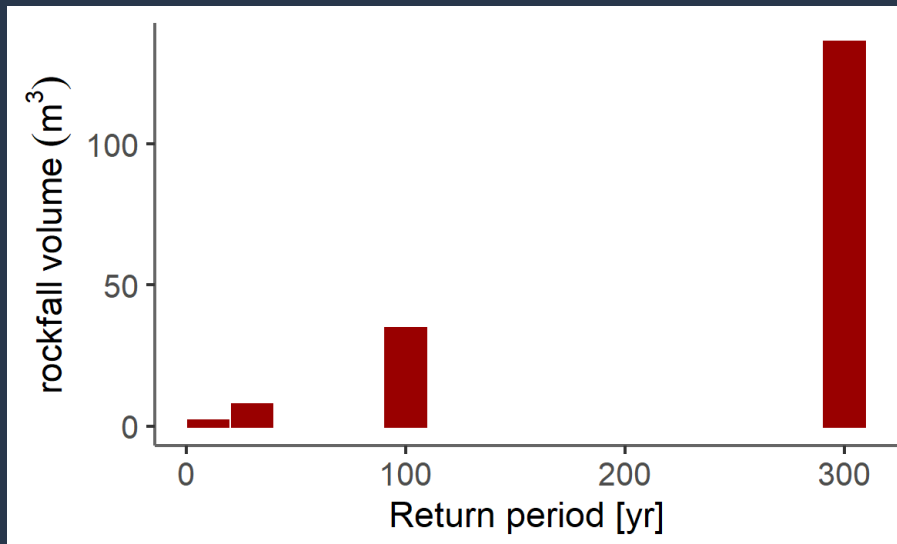
2) Event volume per Scenario («Return period»)

$$V_{sc} = \frac{A_{st} * S^{1/B}}{1/RP}$$

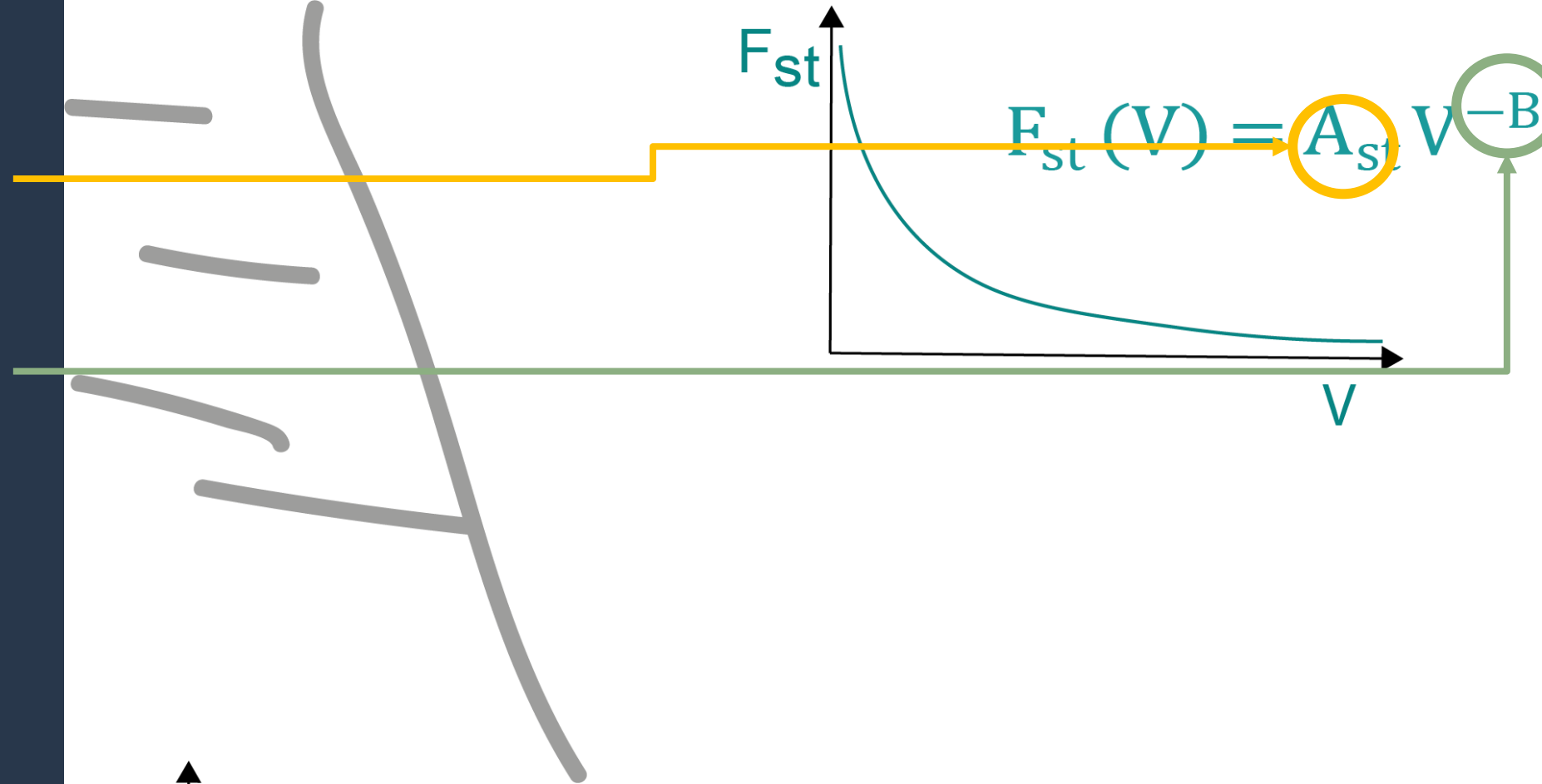
3) «Largest block volume» per event

$$a = \frac{V_{sc}(1-b)}{v_{MAX}^{1-b} - bv_{min}^{1-b}}$$

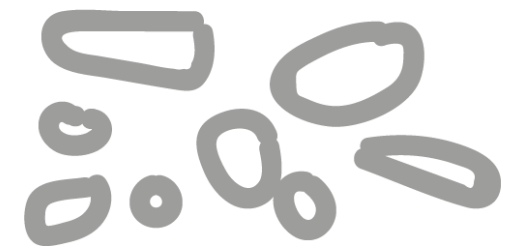
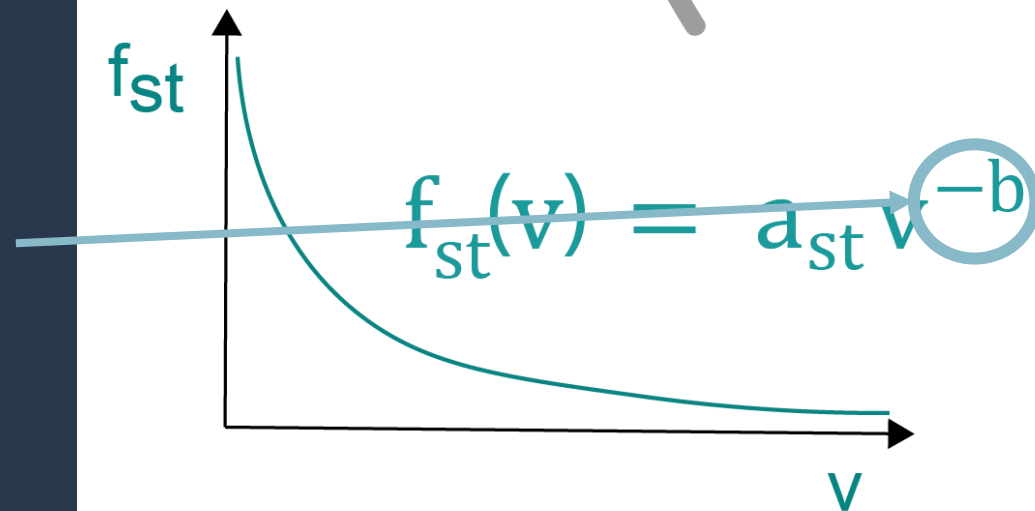
$$v_{max}(V_{sc}) = a^{1/b}$$



Geological structure
(distance
between
discontinuities)
(blockiness in
rock face)



Block distribution
below rock
face

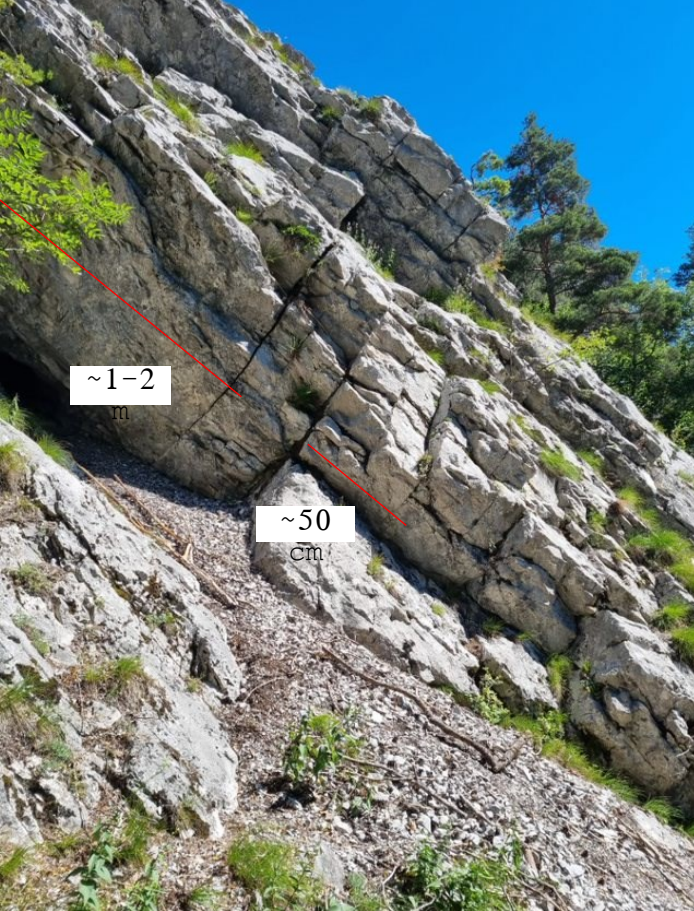


Parameter A

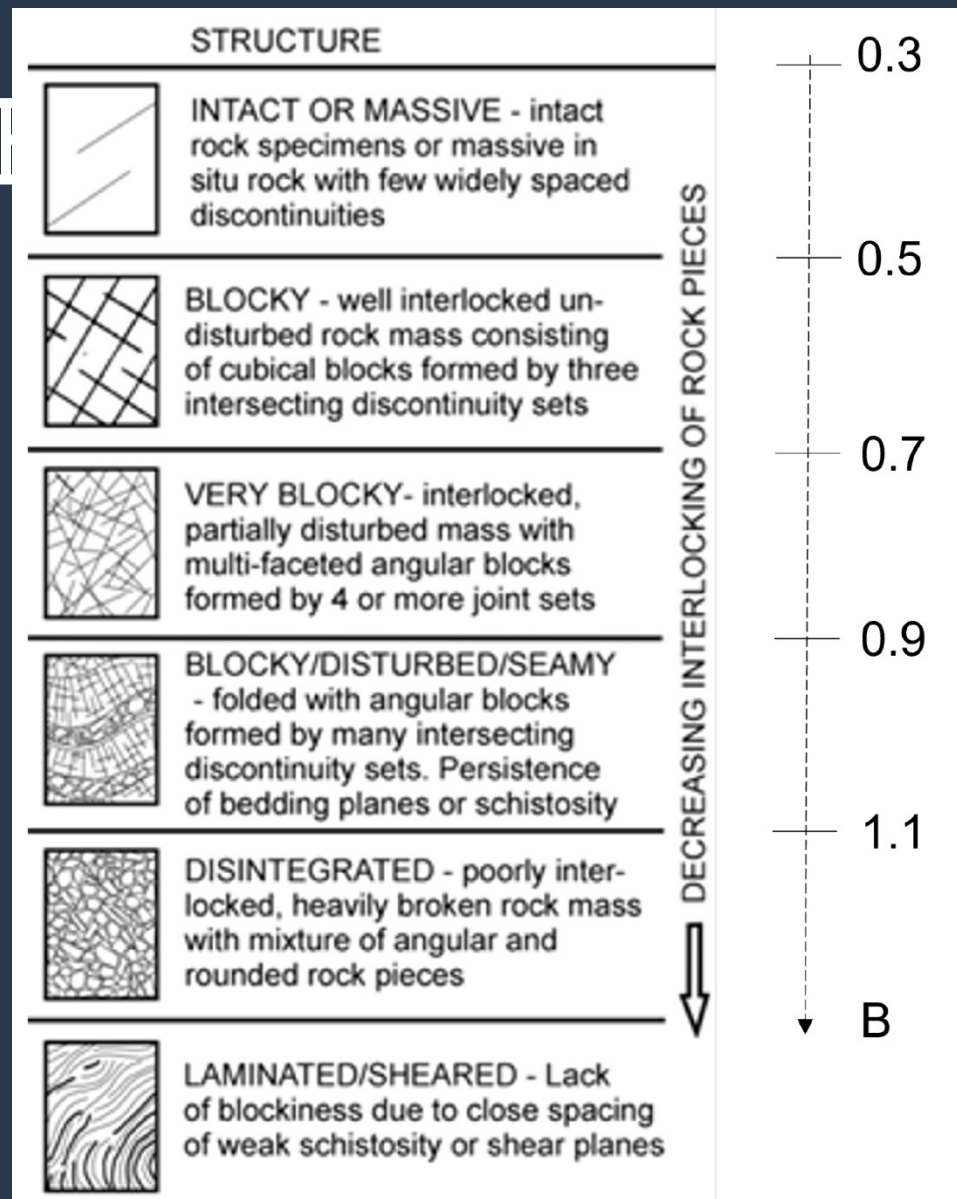
- Aktivitiy of the rock face
- «average distance between main dicontinuities» (s)

- Metrical distance: 0.01-0.1 $\text{m}^3\text{ha}^{-1}\text{yr}^{-1}$
- Decimetrical distance: 0.1-1 $\text{m}^3\text{ha}^{-1}\text{yr}^{-1}$

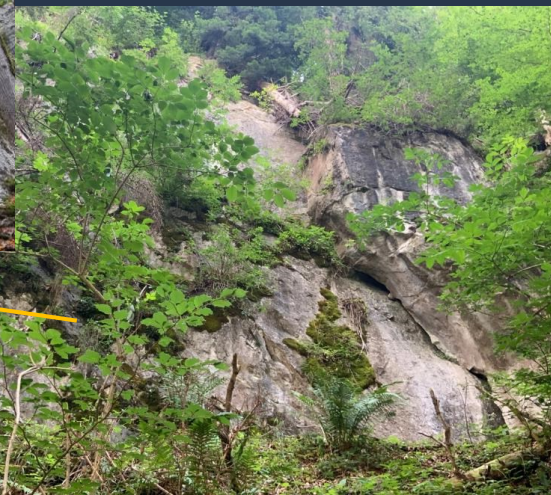
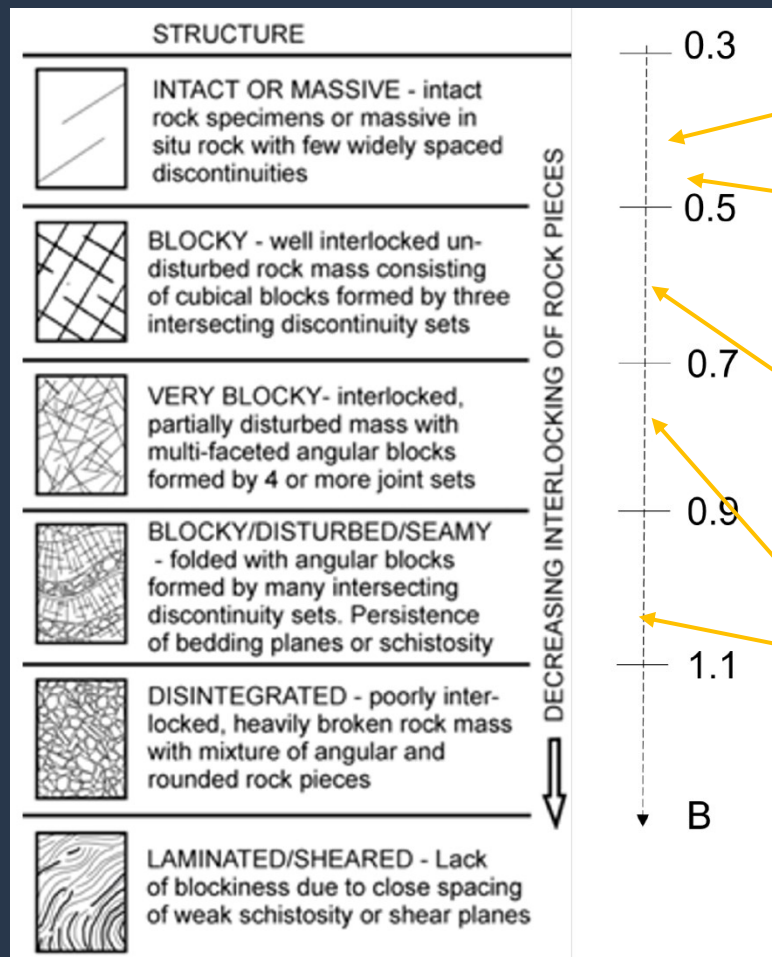




Parameter R



after Hoek, 2007

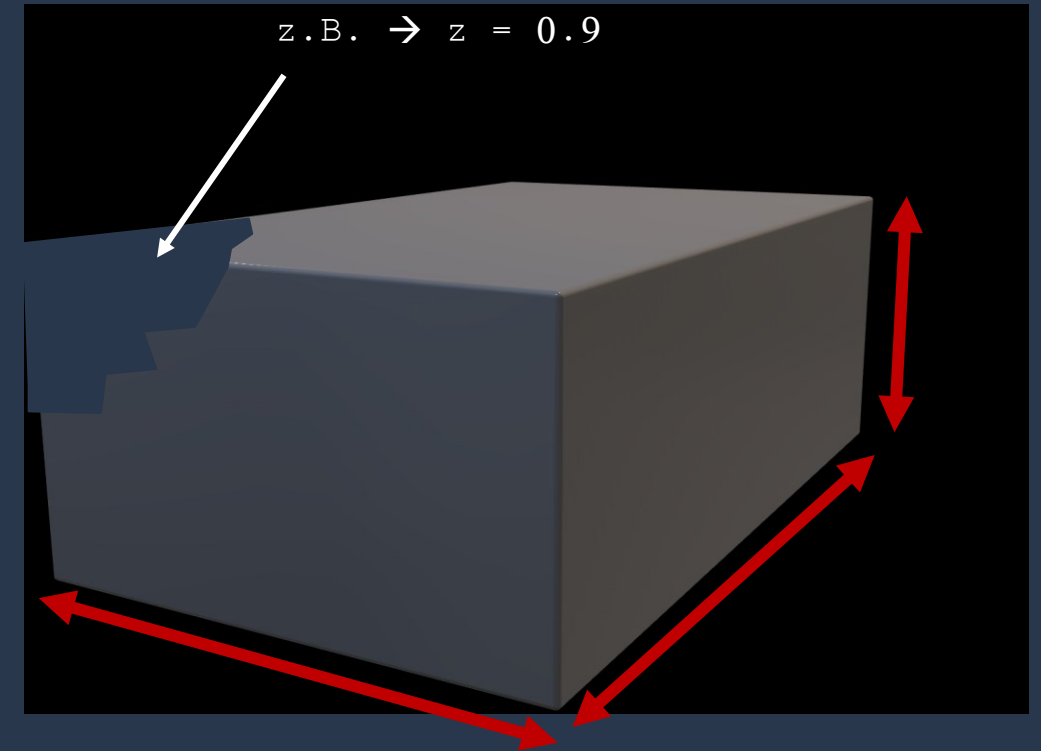


Parameter b

- Recording block volume distribution in the representative zones below the rock face



Block recording



$$a \times b \times c \times z^* =$$

V [m³] * Korrekturfaktor für die Form des Blocks

