



Supplement of

Probability indication maps for avalanche runout for decision support in daily traffic rout risk management

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S1 Example input values for Brämabüel 2019

In the following section, we present the data used to calculate the probability indication map for the Brämabüel case study in 2019. We calculated all the probability indication maps at 12:00 o'clock the day before the avalanches were artificially released.

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- The SNOWPACK simulations were forced with meteorological and snow-cover input data from the IMIS stations, including air temperature, relative humidity, wind speed and direction, radiation, snow height, surface temperature, and snow temperatures within the snowpack. Based on the SNOWPACK simulations at the IMIS stations, we derived the release depths shown in Table S1. The SLF2 station is located lower in the valley and was therefore not used directly to calculate the release height. Instead, it was used to estimate the temperature and snow-height gradients. The release temperature was calculated as the mean temperature across the weak layer. As a simplification, we used the average release temperature of approximately -8°C and added a colder sensitivity scenario of -9°C .

Table S1. Station-based input values used to derive the release-height scenarios for the Brämabüel 2019 event. The SLF2 station is located lower in the valley and was used only to estimate the temperature and snow-height gradients, not directly for the release-height calculation.

Station	Release temperature ($^{\circ}\text{C}$)	New snow (cm)	Weak layer (cm)
SLF2	-3.0	50	-
WFJ2	-8.2	47	84
DAV2	-9.9	48	71
DAV3	-5.6	51	66
FLU2	-8.4	57	105
PAR2	-8.0	51	61
KLO2	-8.9	50	71

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- In the next step, two additional snow-drift scenarios of +25 cm and +50 cm were added to account for uncertainty in the estimated release height and to represent higher-loading conditions. This resulted in the release-temperature and release-height combinations shown in Table S2. In total, 72 scenarios were generated. The release heights were grouped into 10 cm classes, and the occurrence of each release-height class was counted for each release-temperature scenario. The scenario weights were then calculated as the relative frequency of each class, i.e. as the number of occurrences divided by the total number of scenarios.

Table S2. Release-temperature and release-height scenarios used for the Brämabüel 2019 simulations, including their scenario weights. The two release-temperature scenarios are shown side by side to reduce the vertical extent of the table.

Release temperature ($^{\circ}\text{C}$)	Release height (cm)	Weight	Release temperature ($^{\circ}\text{C}$)	Release height (cm)	Weight
-8	50	0.069	-9	50	0.069
-8	60	0.028	-9	60	0.028
-8	70	0.069	-9	70	0.069
-8	80	0.069	-9	80	0.069
-8	90	0.028	-9	90	0.028
-8	100	0.097	-9	100	0.097
-8	110	0.056	-9	110	0.056
-8	120	0.042	-9	120	0.042
-8	130	0.028	-9	130	0.028
-8	140	0.000	-9	140	0.000
-8	150	0.000	-9	150	0.000
-8	160	0.014	-9	160	0.014

Table S3. Release-temperature and release-height scenarios used for the Brämabüel 2025 simulations, including their scenario weights. The two release-temperature scenarios are shown side by side to reduce the vertical extent of the table.

Release temperature (°C)	Release height (cm)	Weight	Release temperature (°C)	Release height (cm)	Weight
−5	40	0.031	−6	40	0.031
−5	50	0.031	−6	50	0.031
−5	60	0.094	−6	60	0.094
−5	70	0.109	−6	70	0.109
−5	80	0.094	−6	80	0.094
−5	90	0.031	−6	90	0.031
−5	100	0.094	−6	100	0.094
−5	110	0.000	−6	110	0.000
−5	120	0.016	−6	120	0.016

Table S4. Release-temperature and release-height scenarios used for the Breitzug 2025 simulations, including their scenario weights. The two release-temperature scenarios are shown side by side to reduce the vertical extent of the table.

Release temperature (°C)	Release height (cm)	Weight	Release temperature (°C)	Release height (cm)	Weight
−5	40	0.031	−6	40	0.031
−5	50	0.031	−6	50	0.031
−5	60	0.078	−6	60	0.078
−5	70	0.031	−6	70	0.031
−5	80	0.078	−6	80	0.078
−5	90	0.031	−6	90	0.031
−5	100	0.016	−6	100	0.016
−5	110	0.016	−6	110	0.016
−5	120	0.031	−6	120	0.031
−5	130	0.016	−6	130	0.016
−5	140	0.078	−6	140	0.078
−5	150	0.000	−6	150	0.000
−5	160	0.047	−6	160	0.047
−5	170	0.016	−6	170	0.016

In comparison, in the year 2025 the snow temperature was warmer compared to the 2019 events. The calculated scenarios for the 2025 snowfall are presented in Table S4 for Breitzug and in Table S3 for Brämabüel.

20 S2 Probability indication map based on only one IMIS station

In Figure S1, we show the resulting probability indication map based on the input from only one measurement station for the Brämabüel 2019 case. We chose the station at Weissfluhjoch for this example. For such an approach, there is no way to get an idea about the snowcover gradient for the potential erodible snow initialization and snow temperature in RAMMS::EXTENDED. Hence, we set those gradients to zero.

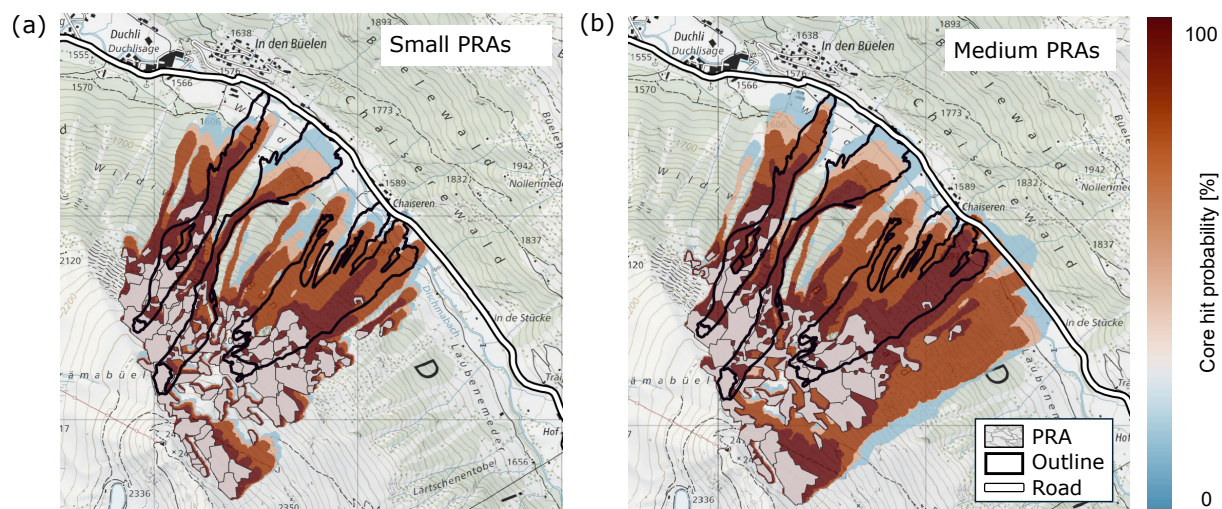


Figure S1. Calculation of the probability indication map for the core for small and medium size release zones at Brämabüel for the 2019 case study based on only one IMIS station WFJ (map source: Federal Office of Topography).