

Extreme snow avalanche events in Tatra Mountains

Pawel Chrustek^{1,2,3,*} Marek Biskupic^{3,4,5} Jozef Richnavsky^{3,6} Milan Lizuch^{3,5} Filip Kyzek^{3,5}



Background

The winter season 08/09 was characterized by the significant amount of snow and the snow precipitation occurred unequally. This phenomenon led to several catastrophic avalanches with return period exceeding 100 years. Several installations and large areas of forest were damaged. Avalanche activity reached its peak at the end of March following the increased amount of snow precipitation, and snow drift.



Fig. 1. Release area and outline of avalanches triggered in Žiarska valley.

Avalanches

During the winter 08/09 many avalanche events in West Tatras were observed. Three of them stick out among the others. Two very large avalanches occurred in Žiarska valley and one in Račková valley. The fracture depth of the largest was varying between 1 and 2.5 m over a width 2000 m. Enormous snow mass was triggered and filled the bottom of the Žiarska valley. The release volume was about 1 300 000 m³. For details see table 1. Luckily none was buried or injured. Snow height in the deposition zone reached 20m and the avalanche remains melted in the summer of 2010. All three avalanches are well documented either by reconnaissance flights or field investigations. Outlines were measured with GPS stations and release areas were estimated from airborne imagery. These data provide valuable information about the behaviour of large avalanches in runout zone and are important input for avalanche runout modelling.

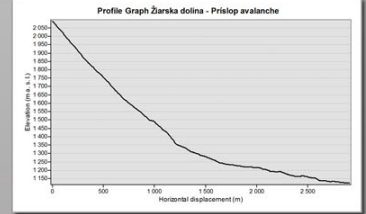


Fig. 2. Continuous fracture resulted in multiple avalanches which deposited enormous amount of snow in the bottom of Žiarska valley.

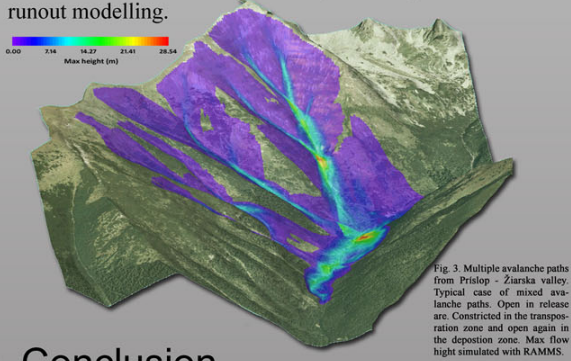
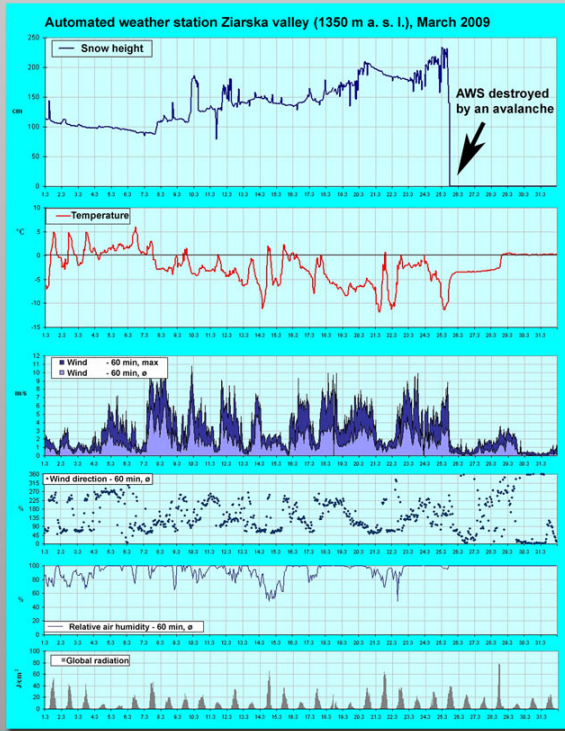


Fig. 3. Multiple avalanche paths from Prislup - Žiarska valley. Typical case of mixed avalanche paths. Open in release area. Constricted in the transportation zone and open again in the deposition zone. Max flow height simulated with RAMMS.

Weather situation in March 2009

On the north slopes of Tatra Mountain, sixty to one hundred cm of fresh snow were recorded in the time from the 16th to 20th of March. Snow was extremely unequally distributed due to the strong winds reaching 45 ms⁻¹. These circumstances led to increased avalanche danger to level 4 out of 5 level scale. Intensive avalanche activity was recorded reaching its peak between 23rd and 26th March, when many catastrophic avalanches were naturally triggered.

Conclusion

Avalanches in West Tatras reached extreme dimensions not only within Tatra Mountains but whole Carpathians. According to the Canadian avalanche classification, two out of three events belong to size 5 classes. These are the largest known avalanches with very high destructive potential. According to the European classification, all three events represent large avalanches. Thanks to the intensive field campaigns, the data for the future avalanche simulations are available.

Avalanche:	Release mode	Type of failure	Path	Form of movement	Contamination of deposits	Damage	Surface length (m)	Vertical displacement (m)	Release area (m ²)	Release volume (m ³)
Ráčková dolina	Natural	Slab	Mixed	Mixed	rock, debris, soil, trees	Forest	1 613	700	260 563	602 211
Žiarska dolina - Bystrý potok	Natural	Slab	Chanelled	Flowing avalanche	rock, debris, soil, trees	Forest	2 521	1 020	200 500	244 494
Žiarska dolina - Prislup, Jalovecké sedlo	Natural	Slab	Mixed	Powder avalanche with flowing component	rock, debris, soil, trees	AMS, Challet, Forest	2 908	1 000	894 700	1 474 996

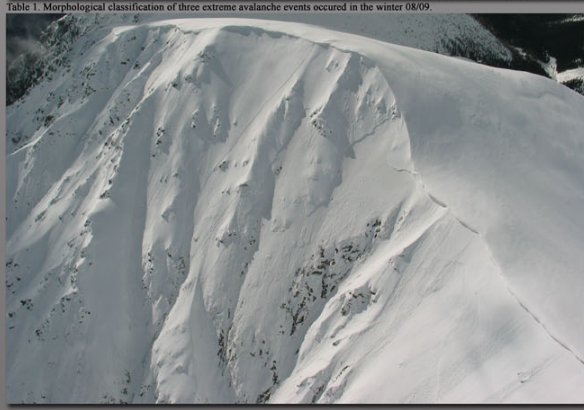


Fig. 7. High snow precipitation in connection with strong wind gust created unstable slabs and cornices located on lee slopes. Example of Račková valley.

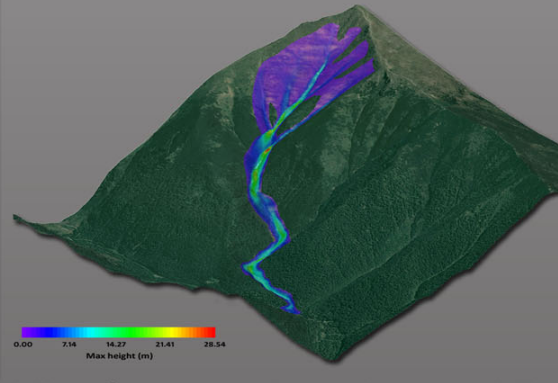


Fig. 5. Bystrý potok in Žiarska valley is typical case of channelled avalanche path. Max flow height simulated with RAMMS.

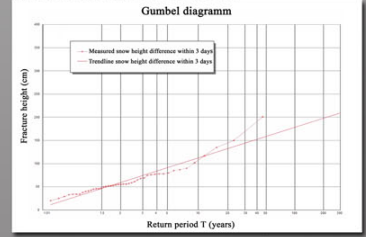


Fig. 4. Gumbel statistics was used to estimate max 3 days differences of snow height. This calculation identifies extreme values of fracture height within return period.



Fig. 5. Runout of Bystrý potok avalanche reached road to Žiarska chalet.

