



Supplement of

Development and evaluation of a method to identify potential release areas of snow avalanches based on watershed delineation

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Supplementary Figure S1: Extracts of the Official French avalanche cadastre "CLPA" (March 2022 edition). Magenta end orange polygons correspond to the extent of past avalanches from i) testimonies and documentary sources and ii) photo-interpretation of landscape footprints, respectively. Full legend at: <u>https://www.avalanches.fr/static/1public/epaclpa/CLPA feuilles carte/CLPA legende carte.pdf</u>. Study areas of Chamonix and Chartreuse/Dent de Crolles are located, as well as the limits of the areas covered by CLPA in both the Mont Blanc (top) and Chartreuse (bottom) massifs.



Supplementary Figure S2: Principle of watershed delineation using flow direction: (a) Local slope for a central pixel and its eight neighbours (adapted from Kinner, 2003) (b) Calculation of flow direction (adapted from Stojkovic et al., 2012) (c) Result: flow accumulation.



Supplementary Figure S3: Histogram of the distance to the closest ridge for the pixels of the study area of Chamonix (Figure 1).

			With default values	Without minimal elevation filter	Without slope filter	Without distance to ridge filter	Without minimal area filter	Without watershed delineation	Without forest filter	With Corine Land Cover forest	With Theia forest
Validation sample	Total area of PRAs within CLPA (validation sample) [km ²]		1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
	Total number of PRAs within CLPA extents (validation sample)		85	85	85	85	85	85	85	85	85
Detected PRAs	Total area of detected PRAs [km ²]		2.35	2.29	2.29	2.35	3.08	2.43	6.16	2.63	4.12
	Difference in area with regards to default values [km²]		/	-0.06	-0.06	0.00	0.73	0.08	3.81	0.28	1.77
	Difference in area with regards to default values (%)		/	-2.5%	-2.5%	-0.2%	31.1%	3.6%	162.3%	12.0%	75.4%
	Total number of detected PRAs		108	107	107	108	364	23	200	110	137
	Difference in numbers with regards to default values		/	-1	-1	0	256	-85	92	2	29
	Difference in numbers with regards to default values (%)		/	-0.9%	-0.9%	0.0%	237.0%	-78.7%	85.2%	1.9%	26.9%
	Total area of detected PRAs within CLPA extents [km ²]		2.17	2.10	2.10	2.17	2.29	2.27	4.54	2.35	3.29
	Total number of detected PRAs within CLPA extents		94	93	93	94	128	19	108	92	92
Evaluation	True positive rate (recall), Eq. 3	In numbers (%)	87	86.8	87	87	35.2	82.6	54	82.4	67.2
		In areas (%)	92.4	91.8	91.8	92.4	74.2	87.2	73.6	88.6	80
	Difference in recall with regards to default values	In numbers (%)	/	-0.2	0	0	-51.8	-4.4	-33	-4.6	-19.8
		In areas (%)	/	-0.6	-0.6	0	-18.2	-5.2	-18.8	-3.8	-12.4

Supplementary Table S1: Same as Table 5, but for the Chartreuse massif.

			With default values	Without minimal elevation filter	Without slope filter	Without distance to ridge filter	Without minimal area filter	Without watershed delineation	Without forest filter	With Corine Land Cover forest	With Theia forest
Validation sample	Total area of PRAs within CLPA (validation sample) [km ²] Total number of PRAs within CLPA extents (validation sample)		55.72	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7
			1884	1884	1884	1884	1884	1884	1884	1884	1884
Detected PRAs	Total area of d [kn	letected PRAs n ²]	71.6	75.3	203.2	118.5	75.6	97.7	113.8	71.6	86.5
	Difference in area with regards to default values [km²]		/	3.7	131.6	46.9	4.0	26.1	42.2	0.0	14.9
	Difference in area with regards to default values (%)		/	5.2%	183.8%	65.5%	5.6%	36.5%	58.9%	-0.1%	20.8%
	Total number of detected PRAs		2413	2575	1520	3430	5667	526	3276	2664	2794
	Difference in numbers with regards to default values		/	162	-893	1017	3254	-1887	863	251	381
	Difference in numbers with regards to default values (%)		/	6.7%	-37.0%	42.1%	134.9%	-78.2%	35.8%	10.4%	15.8%
	Total area of detected PRAs within CLPA extents [km ²]		67.4	69.3	170.4	85.6	67.3	94.7	84.5	67.4	67.4
	Total number of detected PRAs within CLPA extents		2000	2024	701	2045	2606	285	2039	1992	2034
Evaluation	True positive rate (recall), Eq. 3	In numbers (%)	82.8	78.0	46.0	59.4	46.0	54.2	62.0	74.7	72.2
		In areas (%)	94.0	91.8	83.8	72.2	89.0	96.8	74.2	94.2	77.8
	Difference in recall with regards to default values	In numbers (%)	/	-4.8	-36.8	-23.4	-36.8	-28.6	-20.8	-8.1	-10.6
		In areas (%)	/	-2.2	-10.2	-21.8	-5.0	2.8	-19.8	0.2	-16.2

Supplementary Table S2: Same as Table 5, but for the Maurienne massif.



Supplementary Figure S4: Effect on PRA detection of the minimal elevation threshold, Chartreuse/Dent de Crolles study area. For the PRA detection, the minimal elevation threshold varies, all other factors and the DEM resolution are set to their default values (Figure 3), and forest cover data is from DB forest IGN. Aerial photograph ©IGN 2012. For the determination of the validation sample, all factors and the DEM resolution are set to their default values (Figure 4) and forest cover data is from DB forest IGN.



Supplementary Figure S5: Effect on PRA detection of the slope range, Chartreuse/Dent de Crolles study area. For the PRA detection, the retained slope range varies, all other factors and the DEM resolution are set to their default values (Figure 3), and forest cover data is from DB forest IGN. Aerial photograph ©IGN 2012. For the determination of the validation sample, all factors and the DEM resolution are set to their default values (Figure 4) and forest cover data is from DB forest IGN.

References

Kinner, D. A.: Delineation and characterization of the Boulder Creek. Comprehensive Water Quality of the Boulder Creek Watershed, Colorado, During High-flow and Low-flow Conditions, 2000, 3(4054), 27, 2003. Stojkovic, M., Milivojevic, N., and Stojanovic, Z.: Use of information technology in hydrological analysis. E-society Journal, 105, 2012.