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# Rock glacier inventory of the Vanoise massif (French Alps)

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Interferograms from Sentinel-1 were computed from both Track ??? ASC and Track ??? DESC, between 2016 and 2019. Since the French Alps are located in the Northern hemisphere, only the images acquired between June and October (i.e. in the summer periods) were used, in order to avoid the presence of snow cover, with an exception for a pair of images in February 2019 (with cold snow on most the high elevation terrain, allowing coherent InSAR signal). In detail, 16 interferograms were computed for the Track ??? ASC, 18 interferograms for the Track ??? ASC, using time intervals of 6, 12, 18, 24, 48, 54, 354 and 366 days.

The geomorphological mapping of rock glaciers of the Vanoise was made by Roudnitska et al., 2016, as part of the effort made since 2008 by RTM-ONF (French office in charge of mitigating the natural hazard in mountain regions) and PACTE/UGA EDYTEM/CNRS-USMB laboratories for inventorying rock glaciers in France. The inventorying relies on a combination of photo-interpretation with stereoscopic lenses of printed IGN (French institute of geographic information) air photographs (generally dating from late 90's), observation of recent IGN ortho-photographs (generally dating from 2013, 2014 of 2015, and with a resolution of 0.5 and 0.20 m, accessible on [www.geoportail.gouv.fr](http://www.geoportail.gouv.fr)) and 1/25000 topographic maps, and field inspections.

The study area is the Vanoise massif, a mountain region located between N 45.6° and N 45.2° in the French Alps, covering approximately 2000 km<sup>2</sup>, and reaching 3855 m asl at its highest point (*la Grande Casse*). Though it has no strictly delimited boundaries, the massif is here confounded with the territory of the '*Parc national de la Vanoise*' and it mostly includes the highest parts of the *Arc* and *Isère* rivers watersheds. The mean elevation of the massif is 2325 m asl, and about 60 % of the terrain are above 2500 m asl, and about 4 % are covered with glaciers (Gardent *et al.*, 2015). Because of its topographical and climatic settings, permafrost is largely present (Marcer *et al.*, 2017) in the region, as testified by abundant rock glaciers (n = 537, 41 km<sup>2</sup>). These landforms are mostly located in valleys above 2400 m asl (Monnier, 2004), and more than half of them (n = 363) most probably contain ice (Marcer *et al.*, 2017). Among the actively creeping rock glaciers of the Vanoise massif, 24 landforms presently show evidences of destabilization, such as extensional cracks, crevasses and scarps (Marcer *et al.*, 2019).

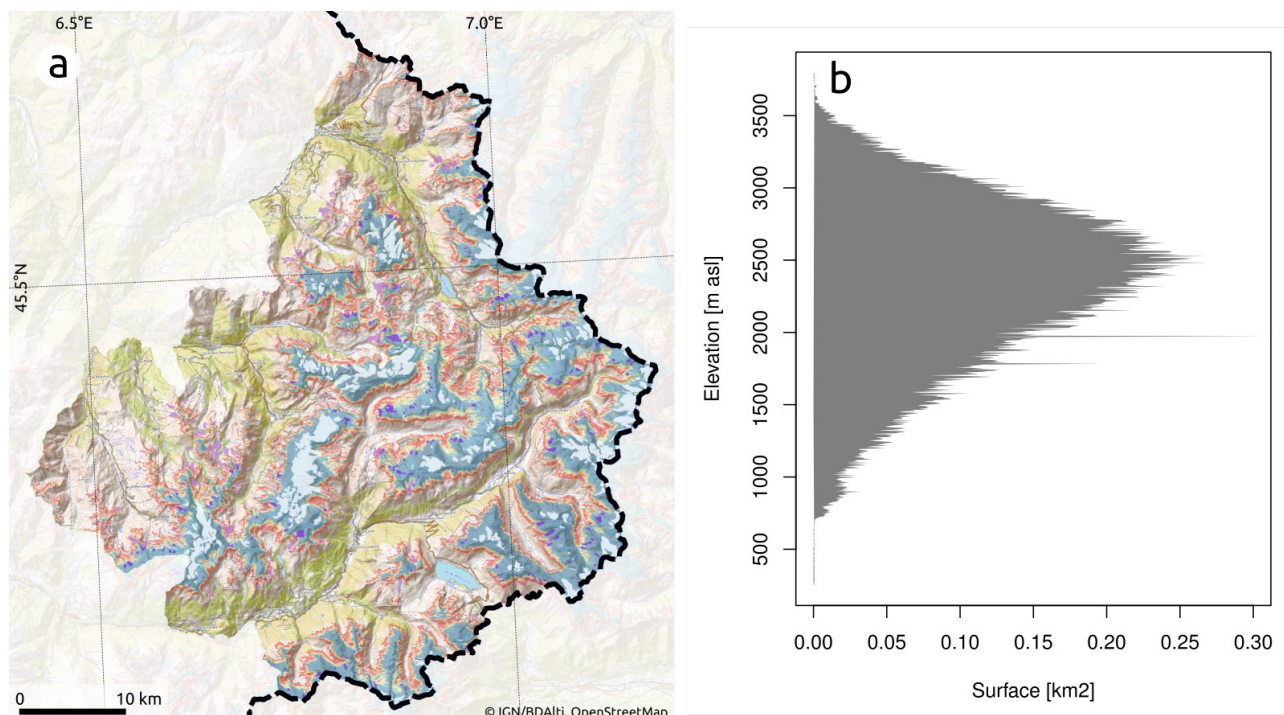


Figure 1: Geographical context (a) and hypsometry (b) of the Vanoise massif.

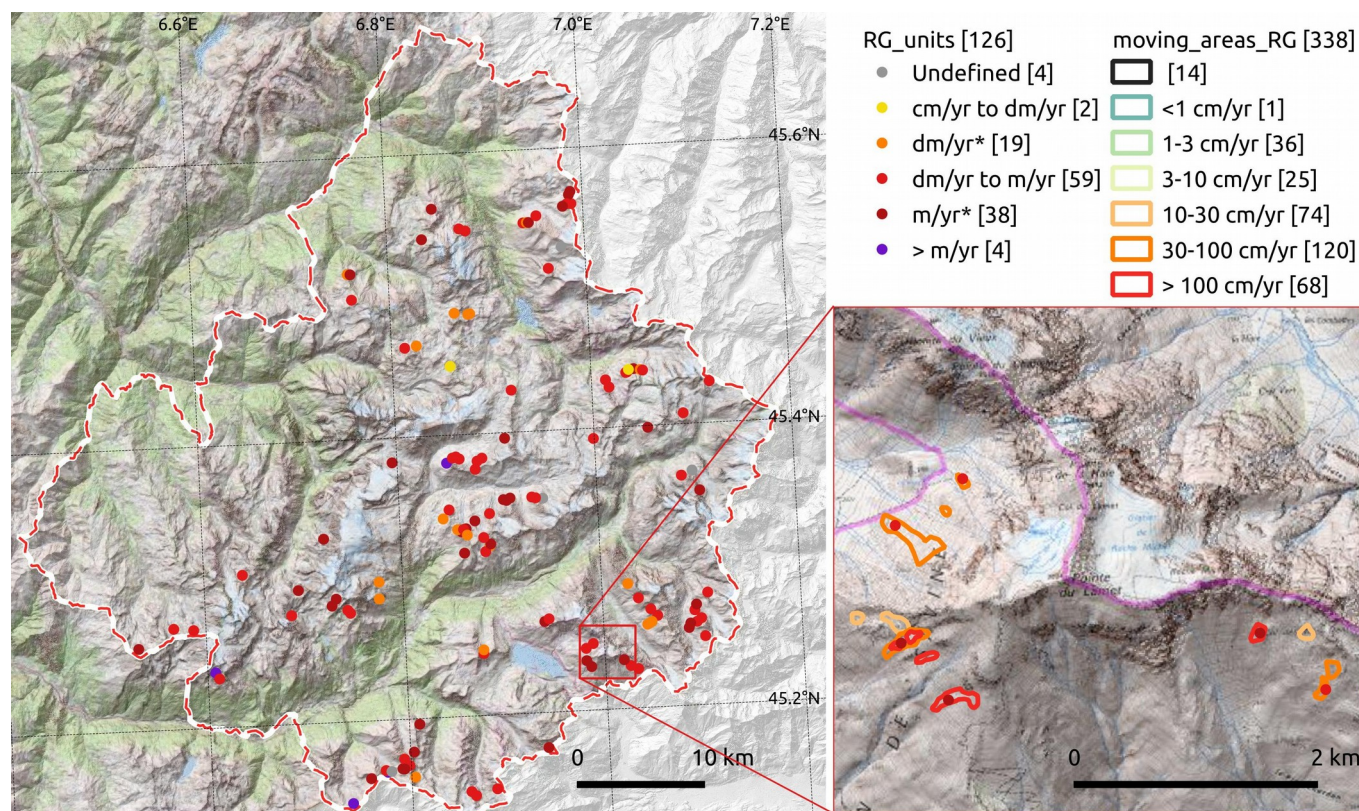
Based on InSAR, 313 moving areas related to rock glaciers were detected. Table 1 contains the number of identified moving areas for each velocity class. The identified rock glacier units with available kinematic information extracted from the previous moving areas are 275. Of those, we classified only 159 RGs for which external information on surface velocity was available (Table 2, and see metadata file for more information).

*Table 1: Number of identified moving area for each velocity class in the Vanoise massif.*

Undefined	< 1 cm/yr	1-3 cm/yr	3-10 cm/yr	10-30 cm/yr	30-100 cm/yr	> 100 cm/yr	Other
11	1	36	25	68	107	65	11

*Table 2: Number of kinematic attributes for each velocity class in the Vanoise massif.*

Undefined	cm/yr to dm/yr	dm/yr	dm/yr to m/yr	m/yr	> m/yr
4	2	19	59	38	4



*Figure 2: InSAR inventory in the Vanoise massif, showing both the moving areas and the classified rock glaciers.*

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