

How kinematics attributes improve geomorphological interpretation of rock glacier?

Preliminary insights from the revision process of the French rock glaciers inventory

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Context



Natural hazards emerging from degrading permafrost in France

- Two marking events affecting rock glaciers (in 2006 and 2015)
- Interest of the *RTM*, French office in charge of mitigating natural hazards in mountain

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- IPA Action group “Rock Glaciers Inventories and Kinematics”

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The revision process of the FRoGI is done in 2 steps:

1) geometry (outlines and new RG) and 2) kinematic characterization

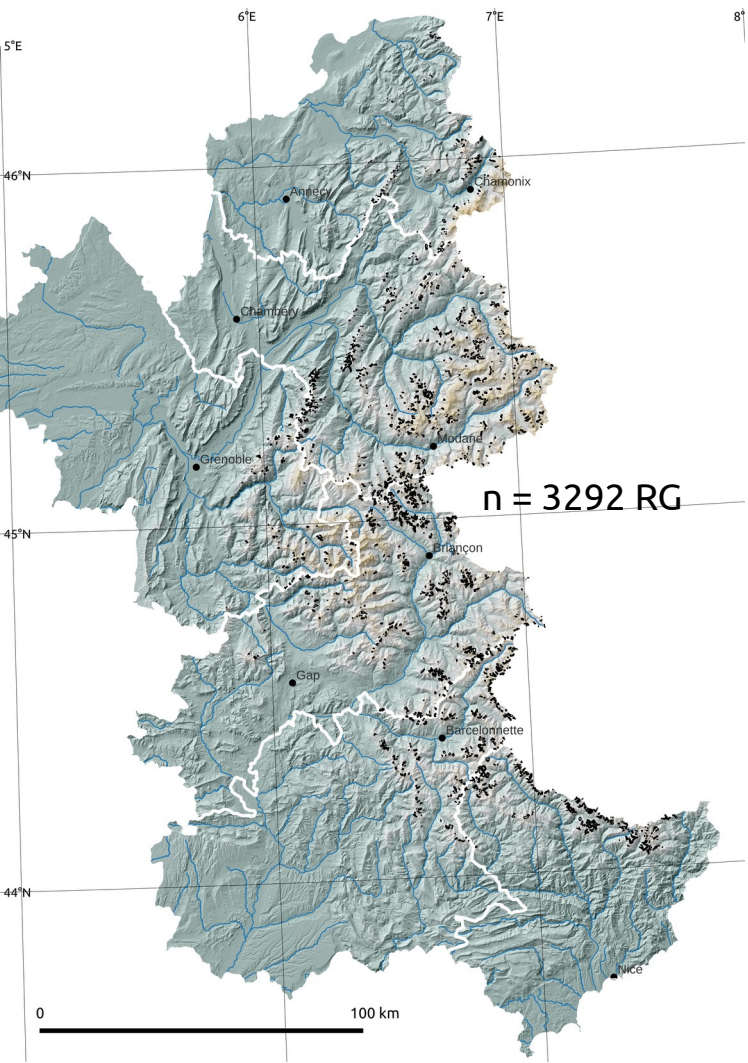
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The French alpine areas:

- 6 administrative *départements*
- 12 000 km² > 1500 m asl. & ~ 180 000 inh. > 1500 m asl.

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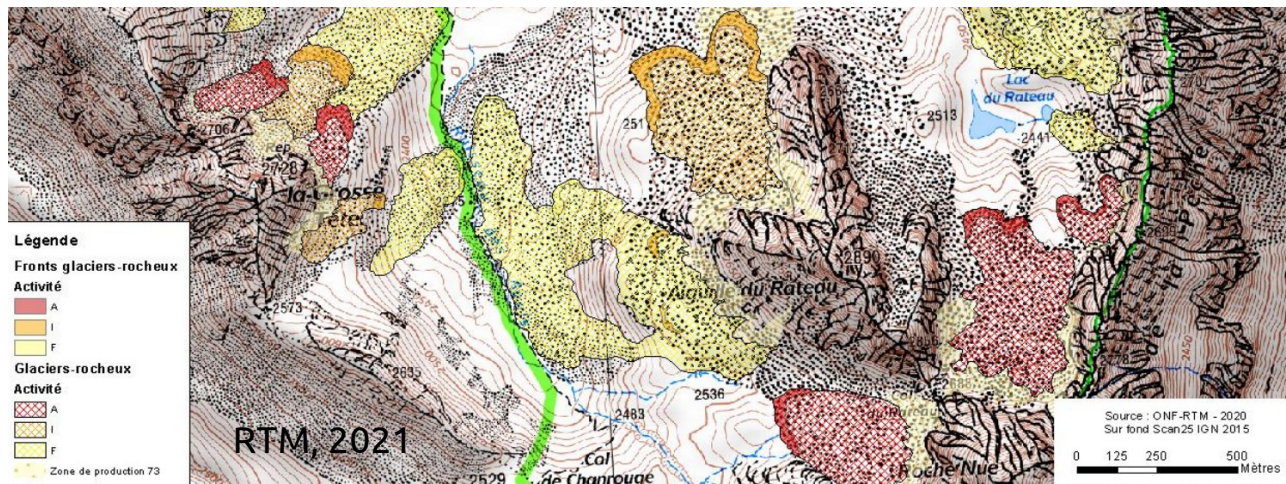


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Initial RG inventory (2009-2016)

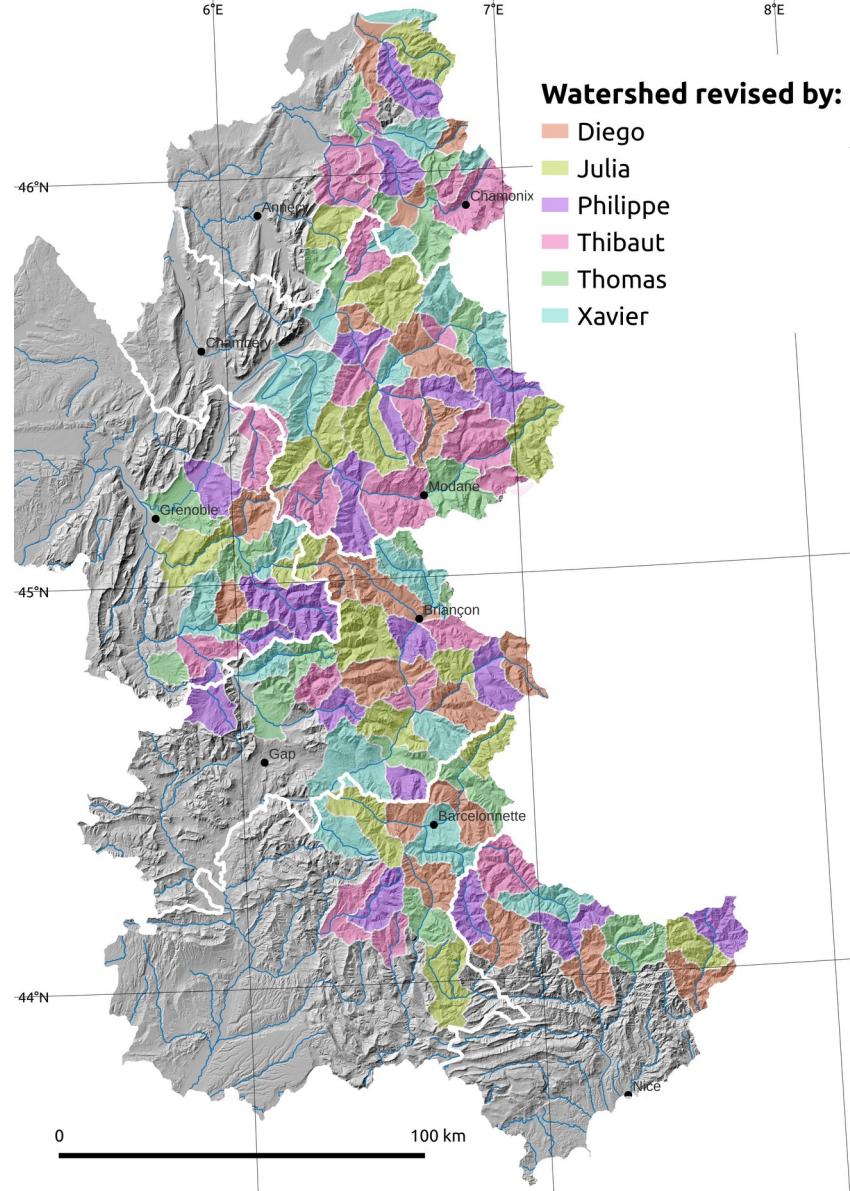
- Supervision by RTM + PACTE & EDYTEM
- ~ 1 *département* / year, mapped by Master students
- IGN ortho-imagery *de l'époque*
- Focus on hazardous RGs



Methodology

1 - Revision by 6 operators

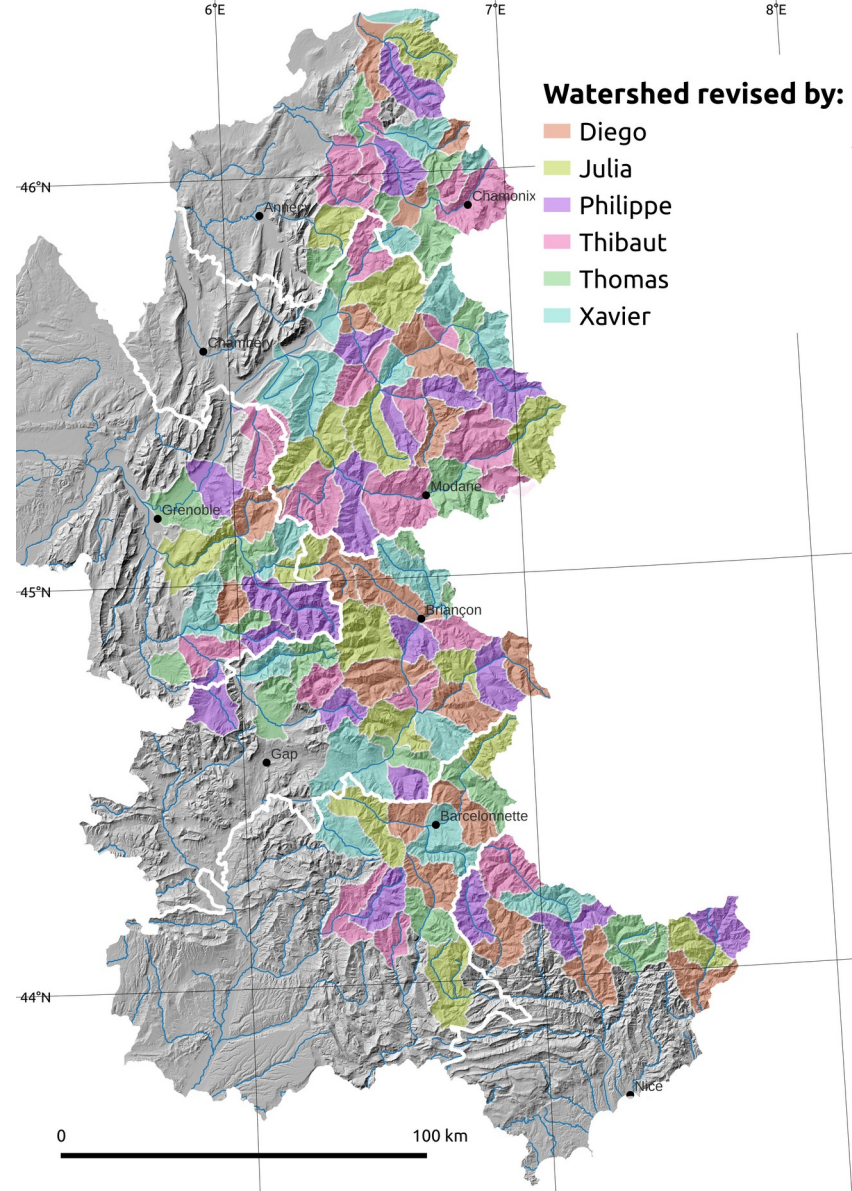
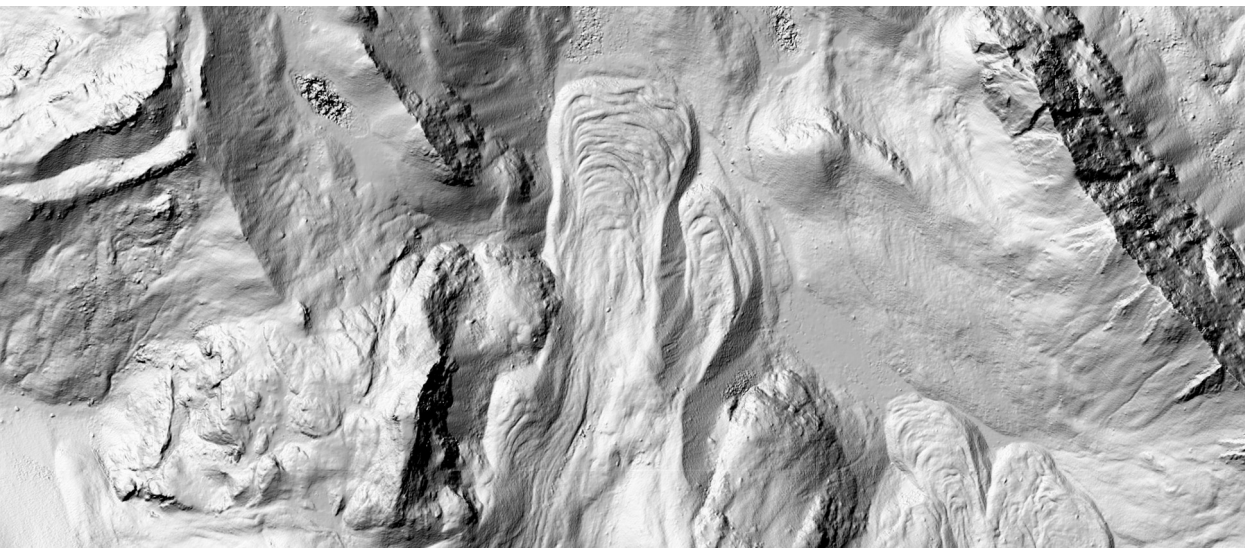
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- Random list of watersheds



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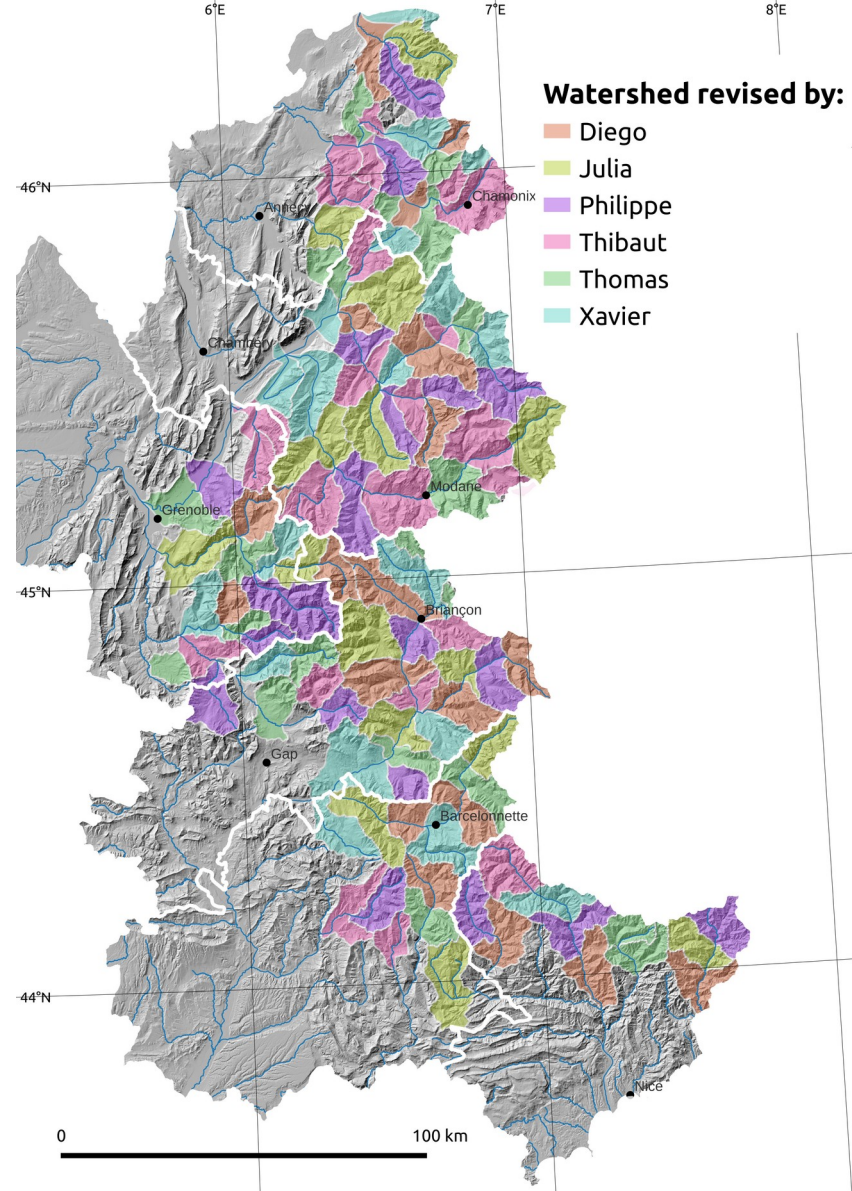
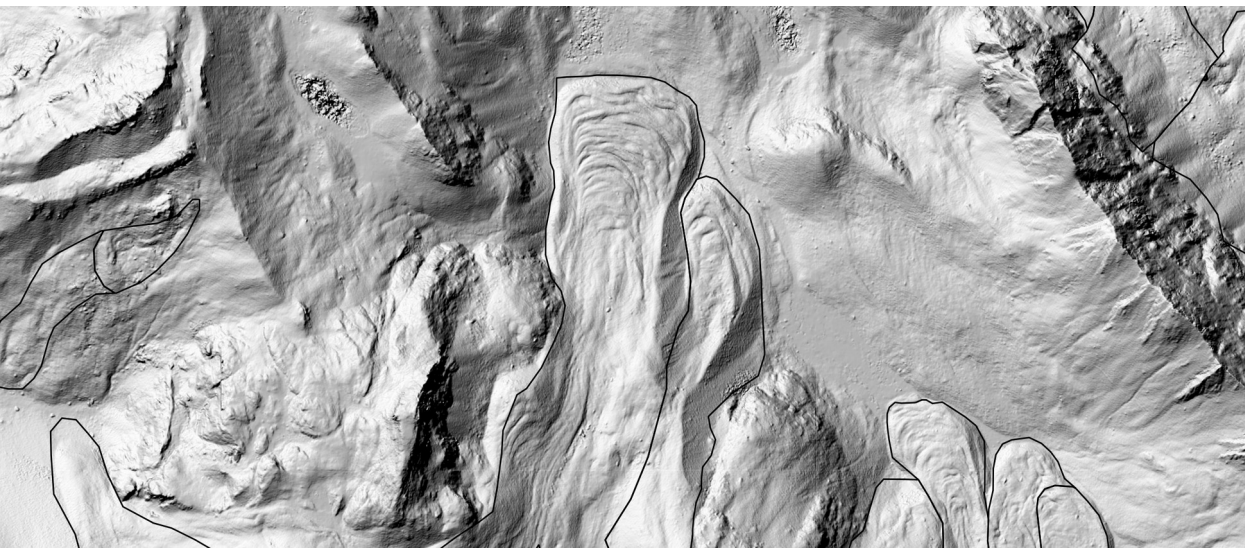


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→ **Only outline and presence/absence have been revised**

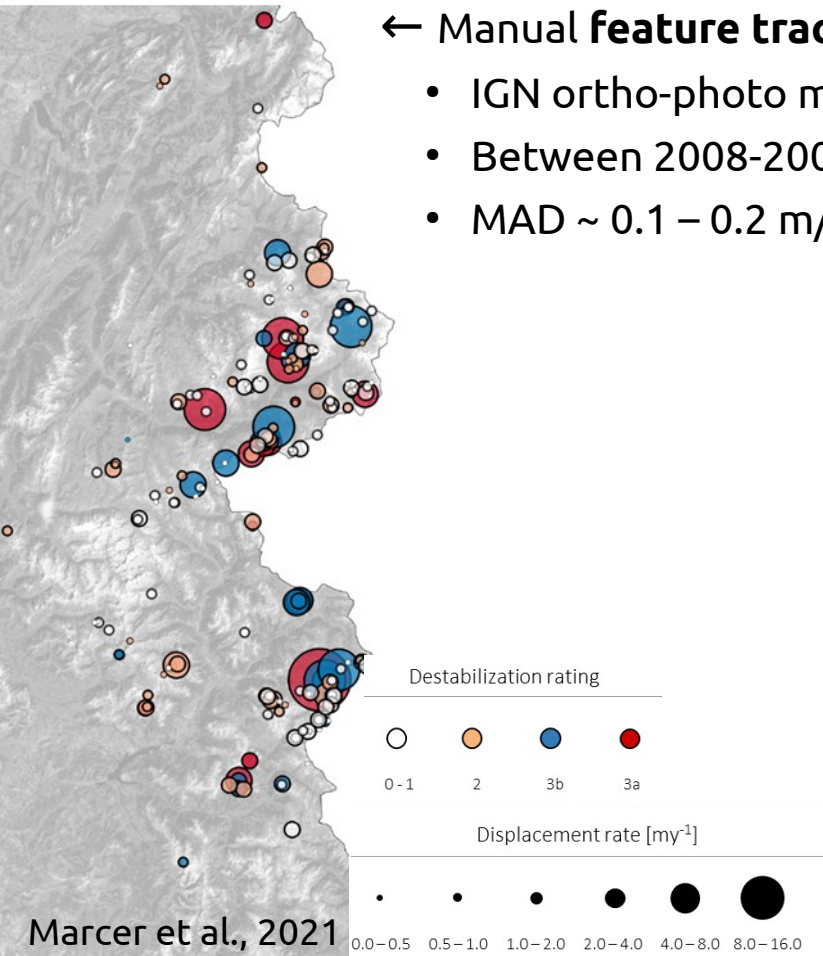


Methodology

2 - Integrating kinematics attributes

← Manual **feature tracking** of blocks

- IGN ortho-photo mosaics (WMS)
- Between 2008-2009 and 2015-2017
- MAD ~ 0.1 – 0.2 m/a



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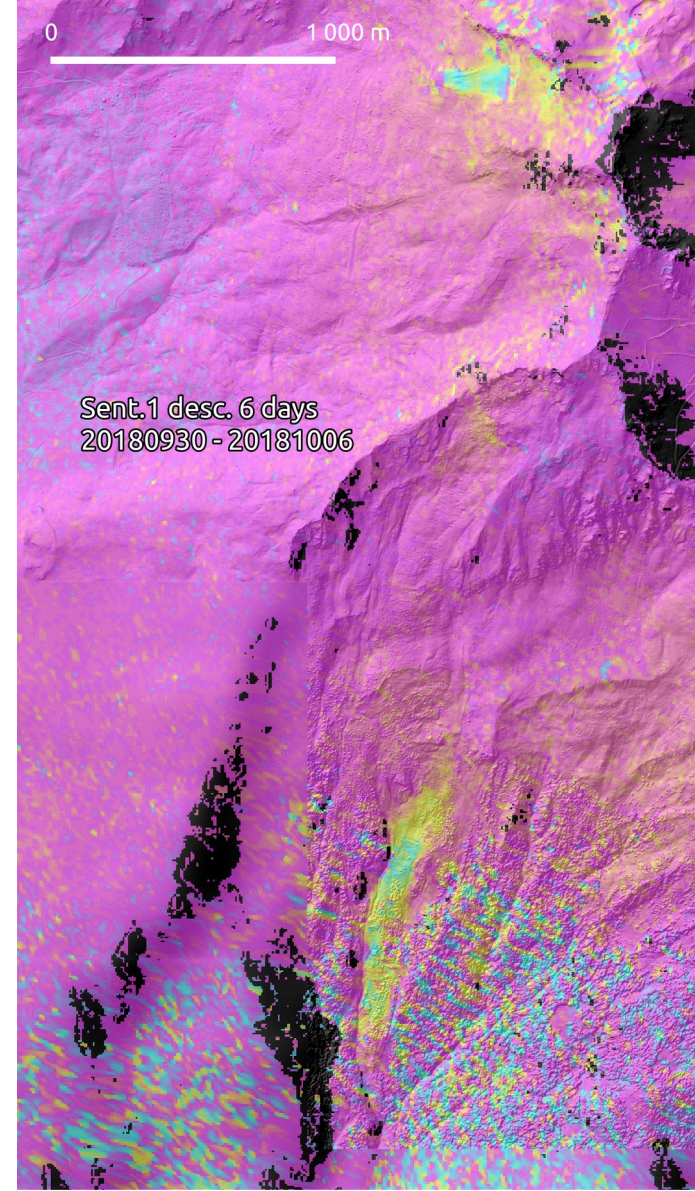
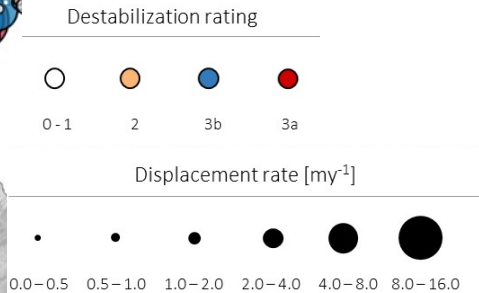
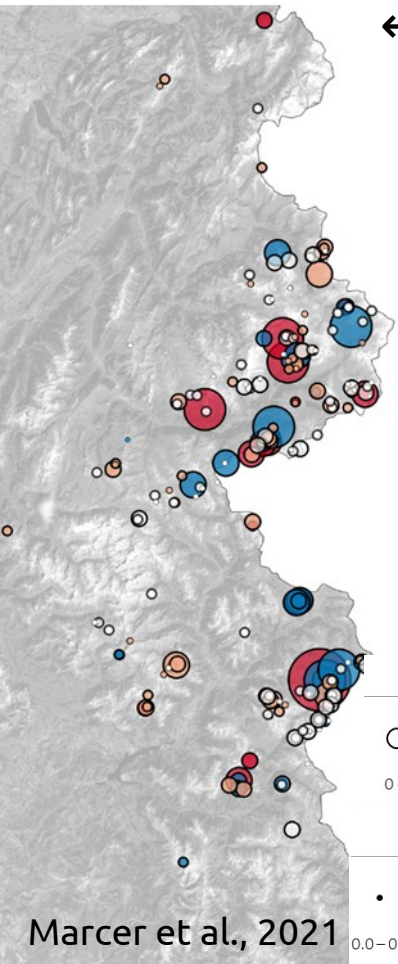
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Manual **detection of movements on InSAR** →

- 132 Sentinel-1 interferograms, over 2018 summer, mostly in descending mode
- Flatsim (NSBAS) 30 m resolution products
- RGIK guidelines



Methodology

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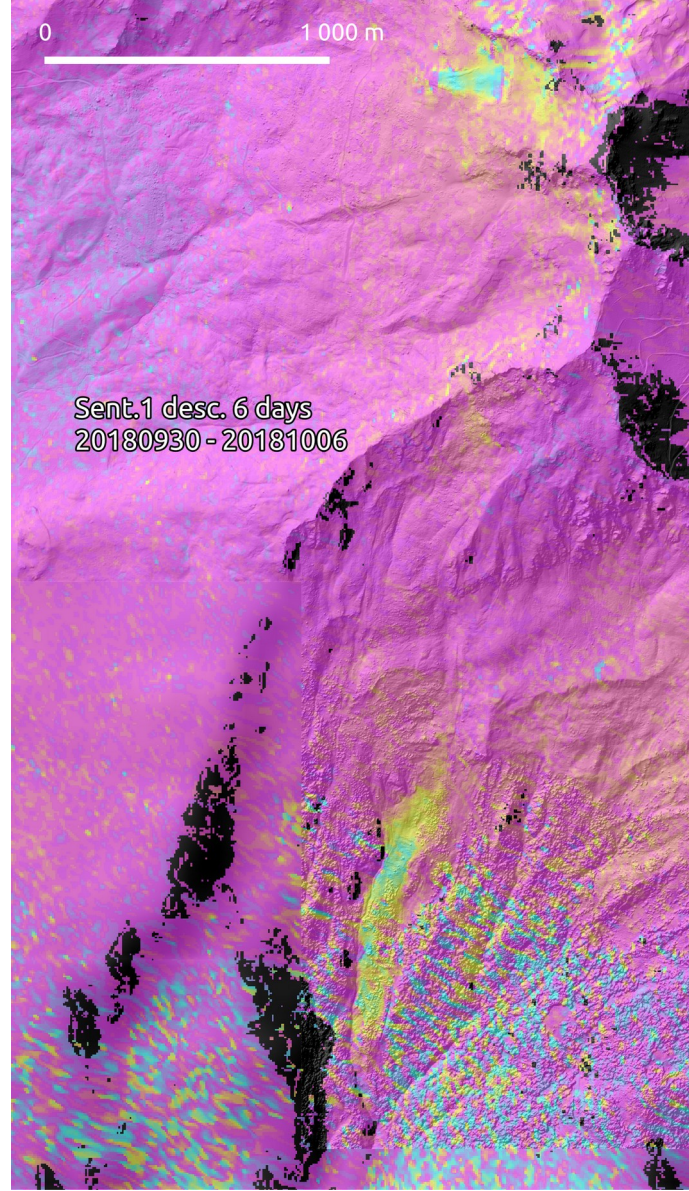
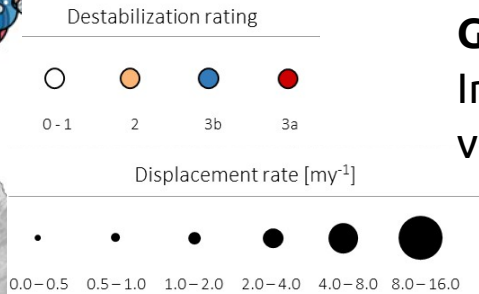
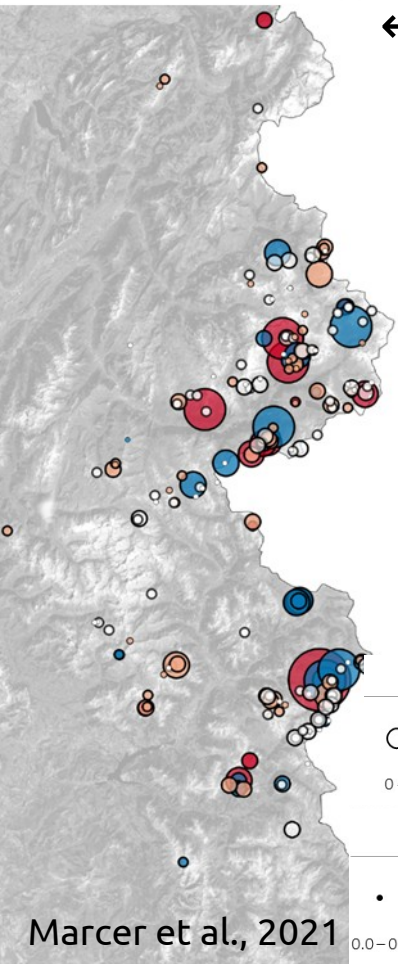
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GIS processing for attributing InSAR classes and optical velocity to RG polygons

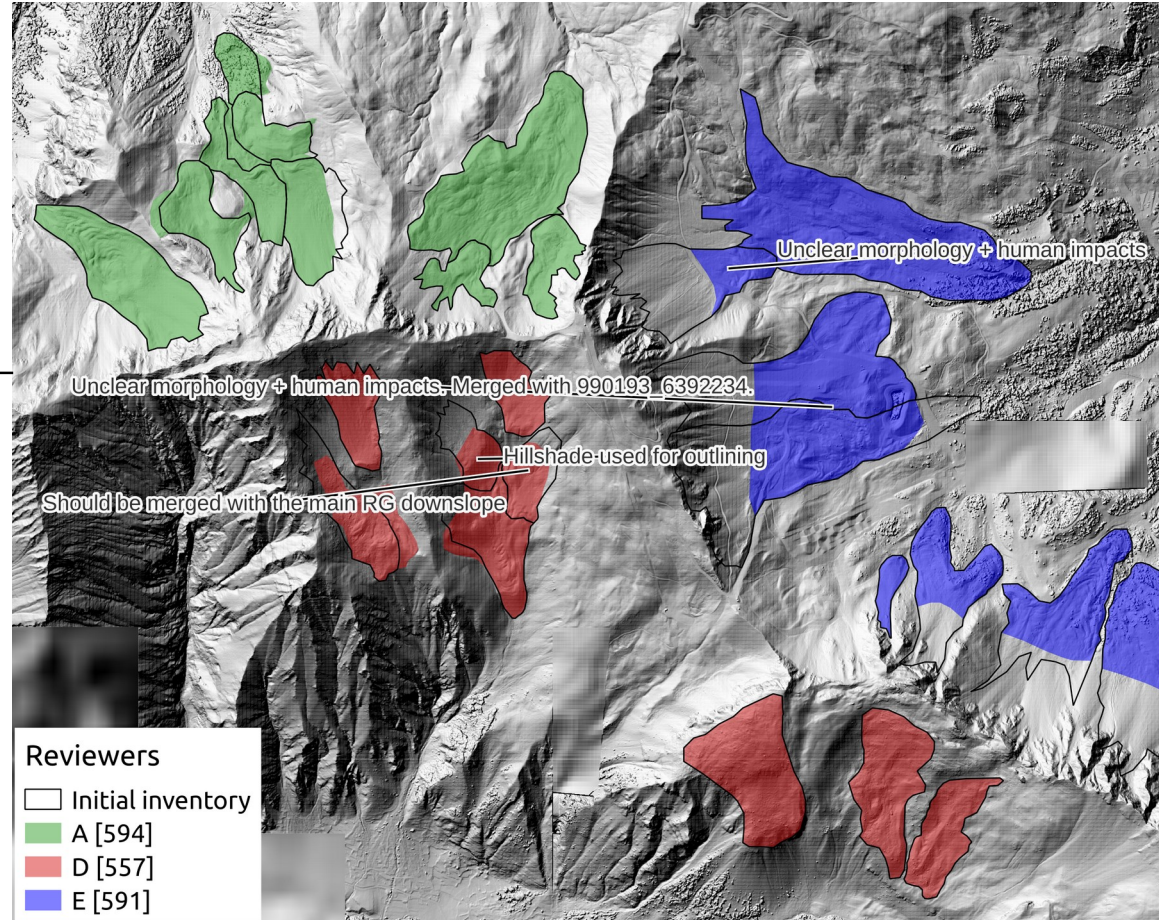


Results

Insights from multi-operator revision

- up to now, *only ~78 % of the initial FroGI completed...*
- 3024 polygons (93 watersheds done, out of the 112)
- Surface: 215 km² (35 km² for active RG)

Category	Operator					Total
	A	B	C	D	E	
New RG	107	28	130	27	65	357
Modified contours	543	213	173	238	188	1355



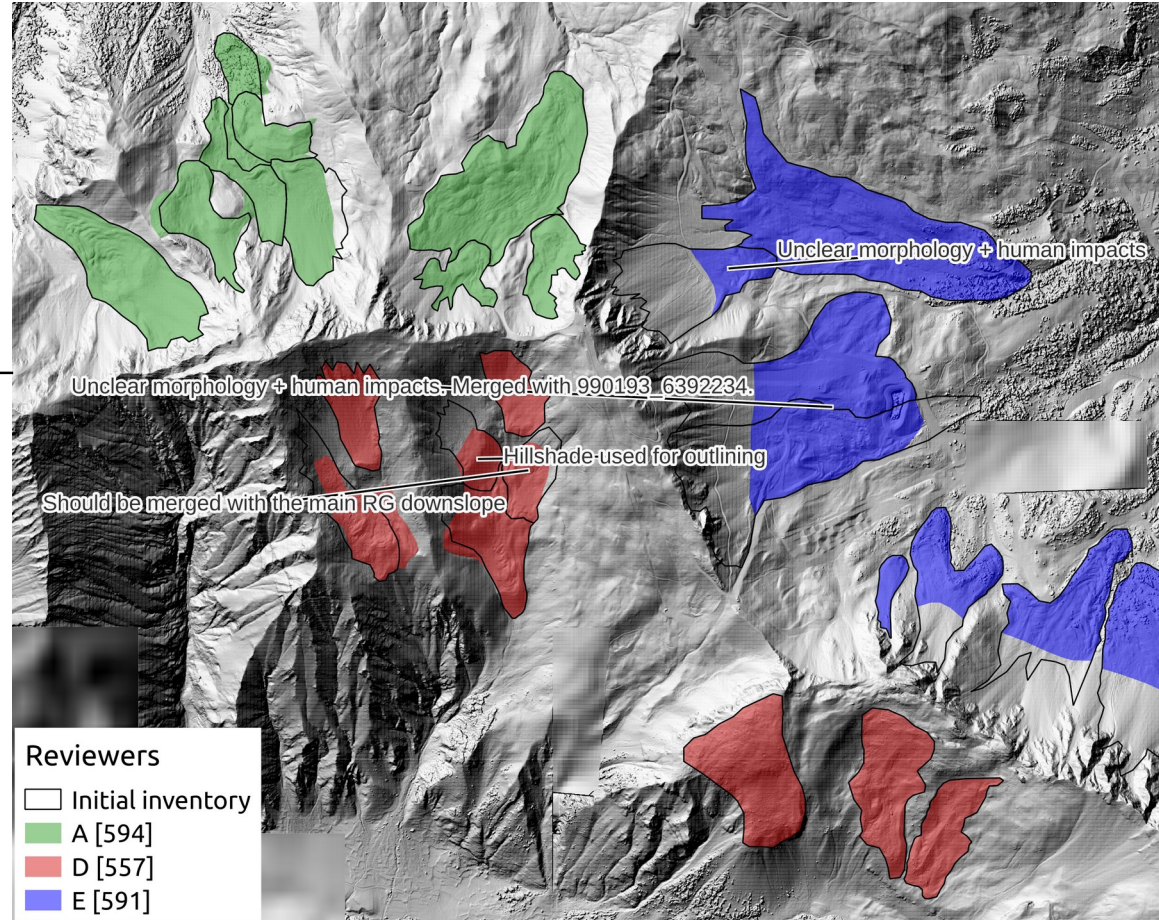
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- Front and lateral limits: good agreement
- Large discrepancy for rooting zones
- Merging / splitting landforms remains problematic

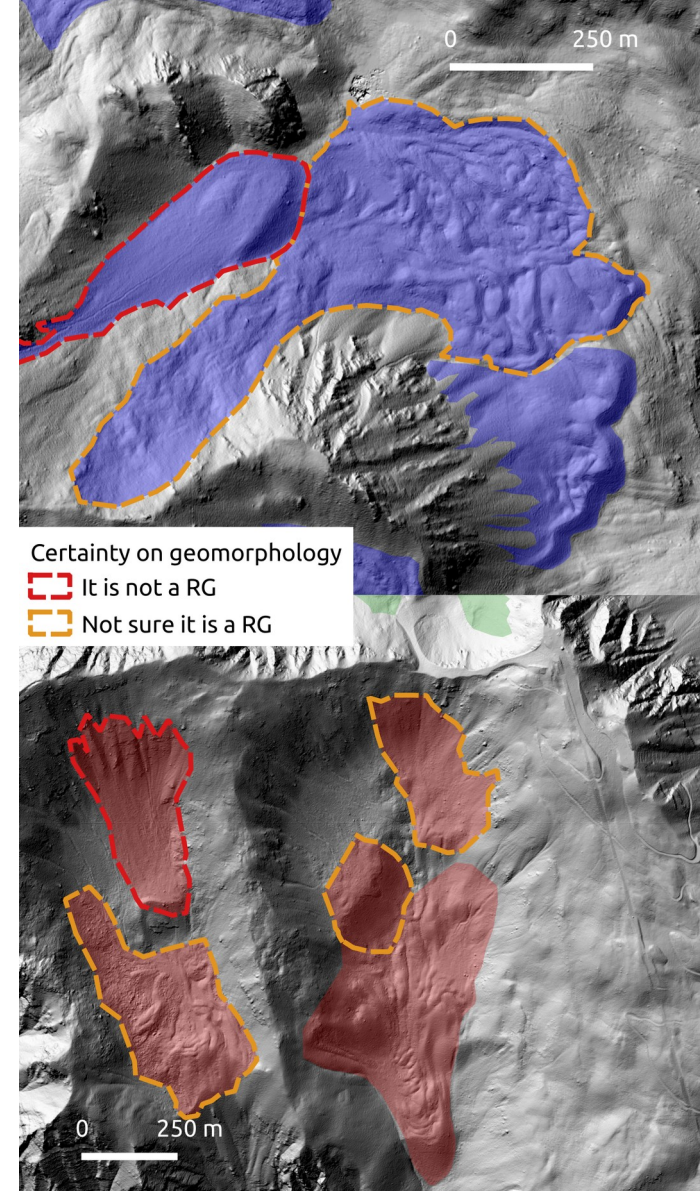


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Geomorphological recognition of the landforms

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Not a RG	18	43	37	26	53	177



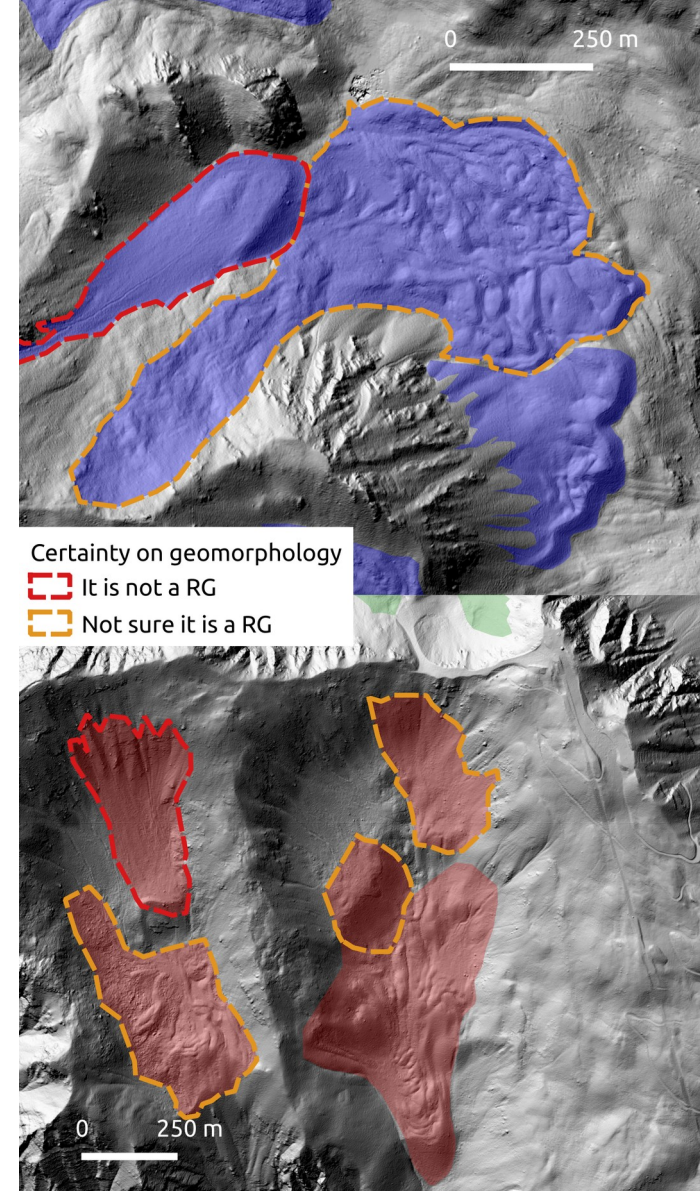
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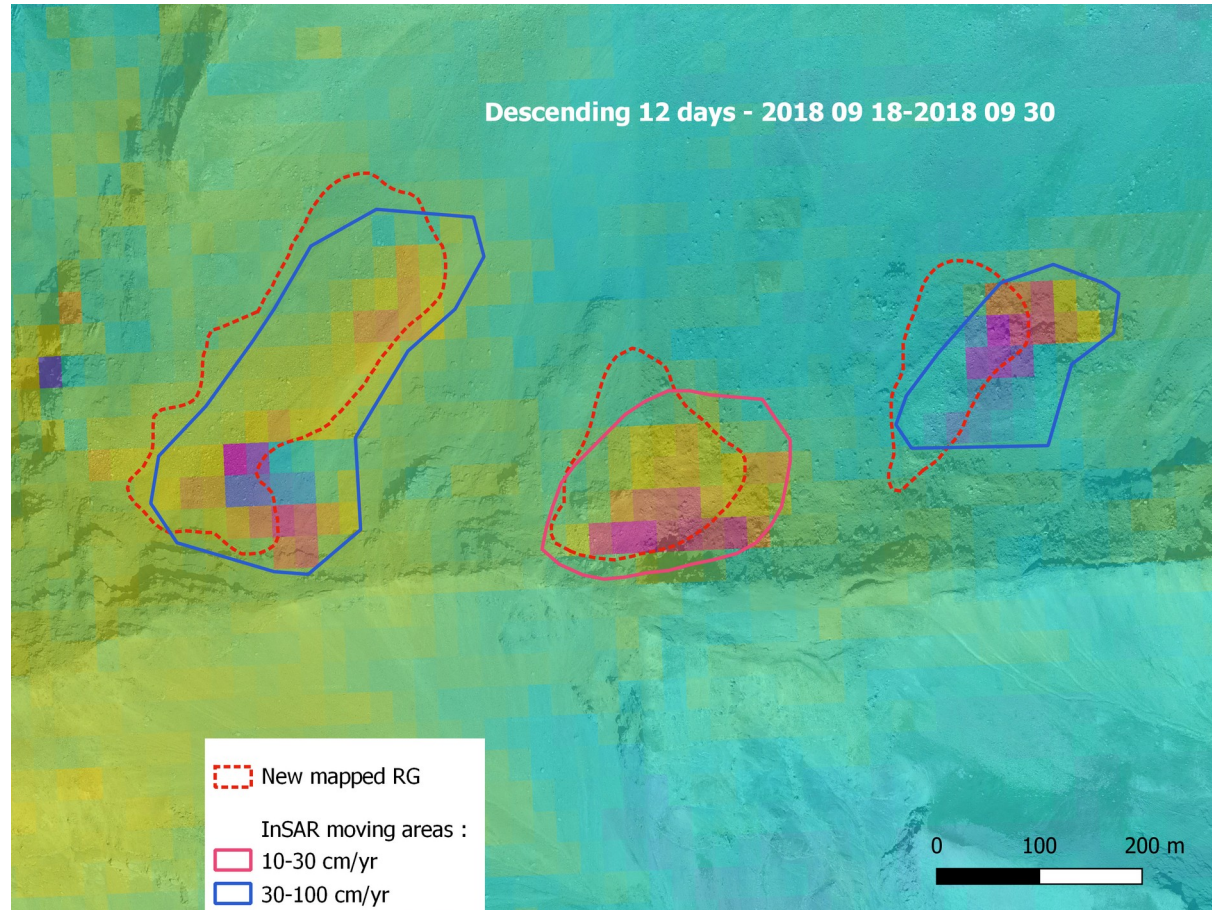
→ **Large inter-operator variability** (similar to Brardinoni *et al.*, 2019)



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Insights from kinematic data

InSAR allows detecting 44 new RGs →
(*mapped by the only operator that used
InSAR...*)

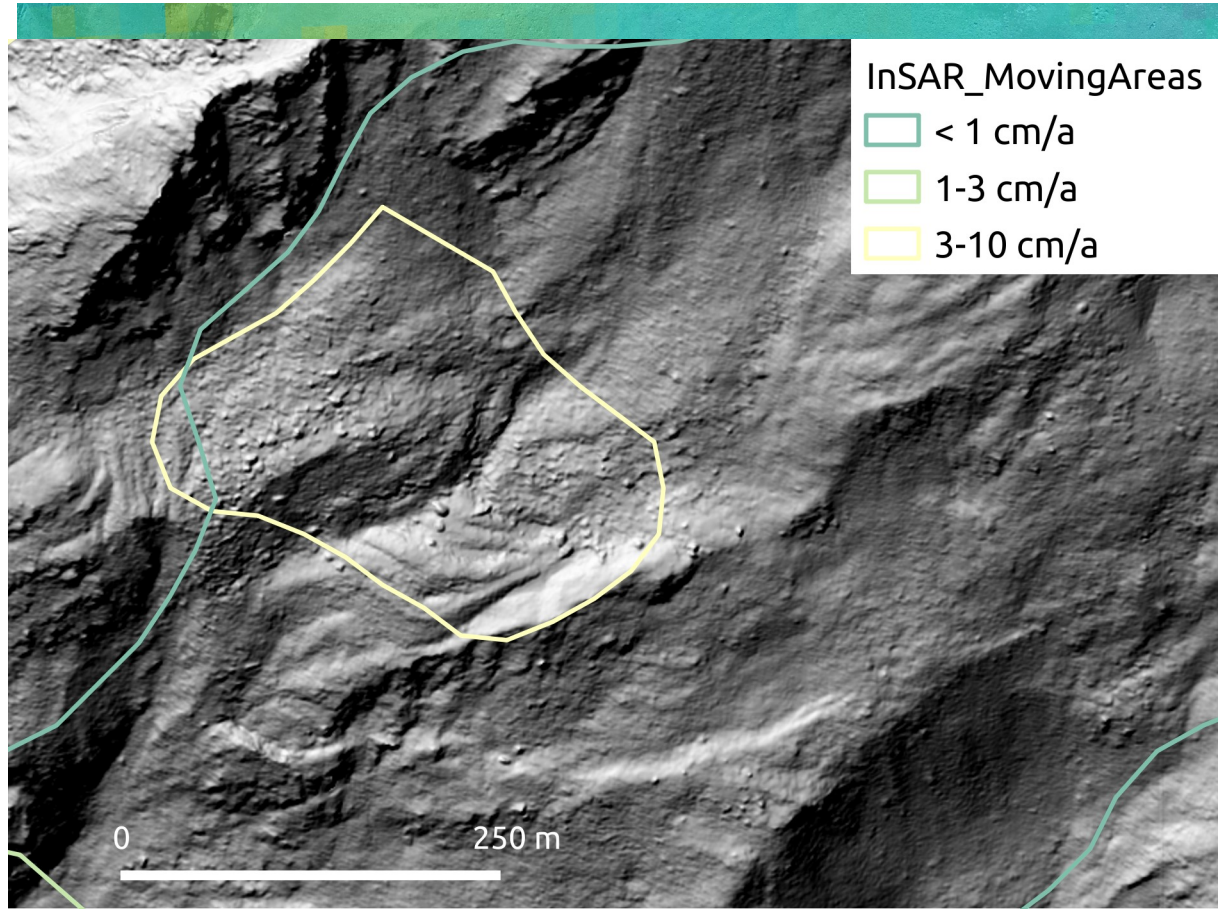


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Also RGs with InSAR moving area →
but not *-yet-* mapped

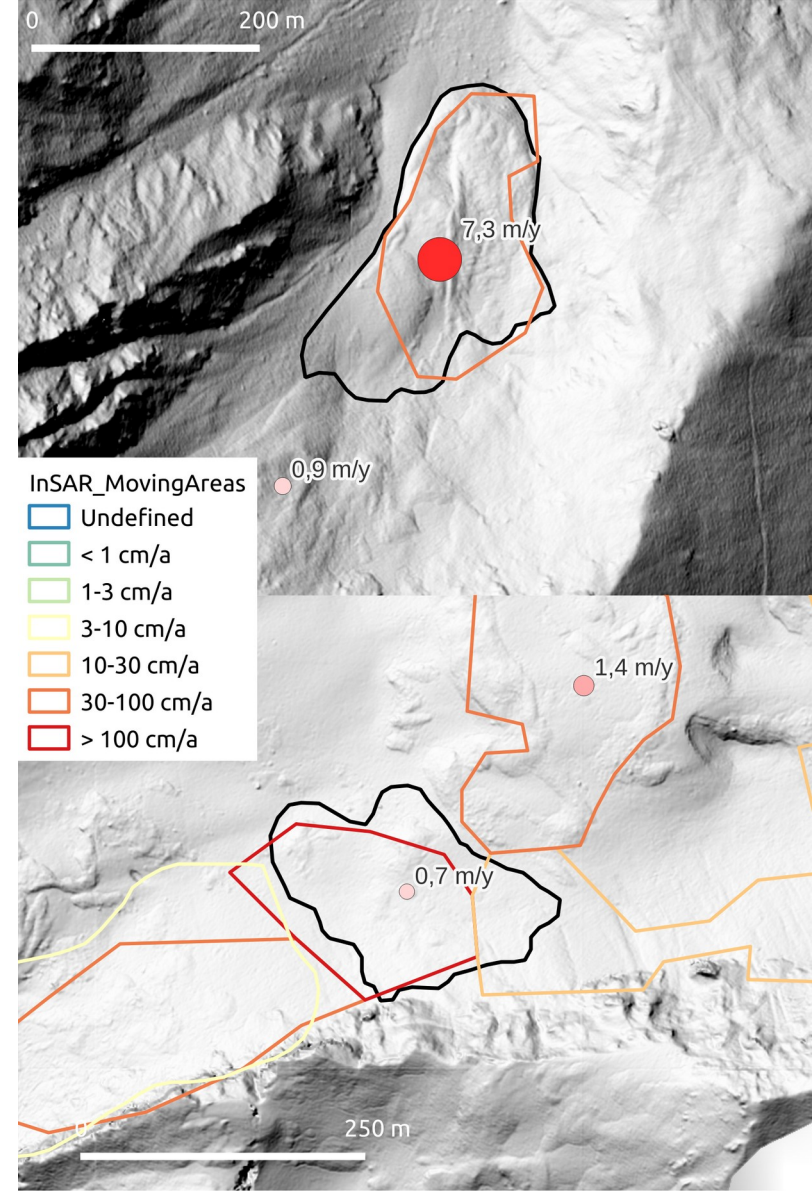


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Re-evaluation of the RG activity

Ex. of Relict RGs with InSAR KA > 10-30 cm/a (total = 26) →



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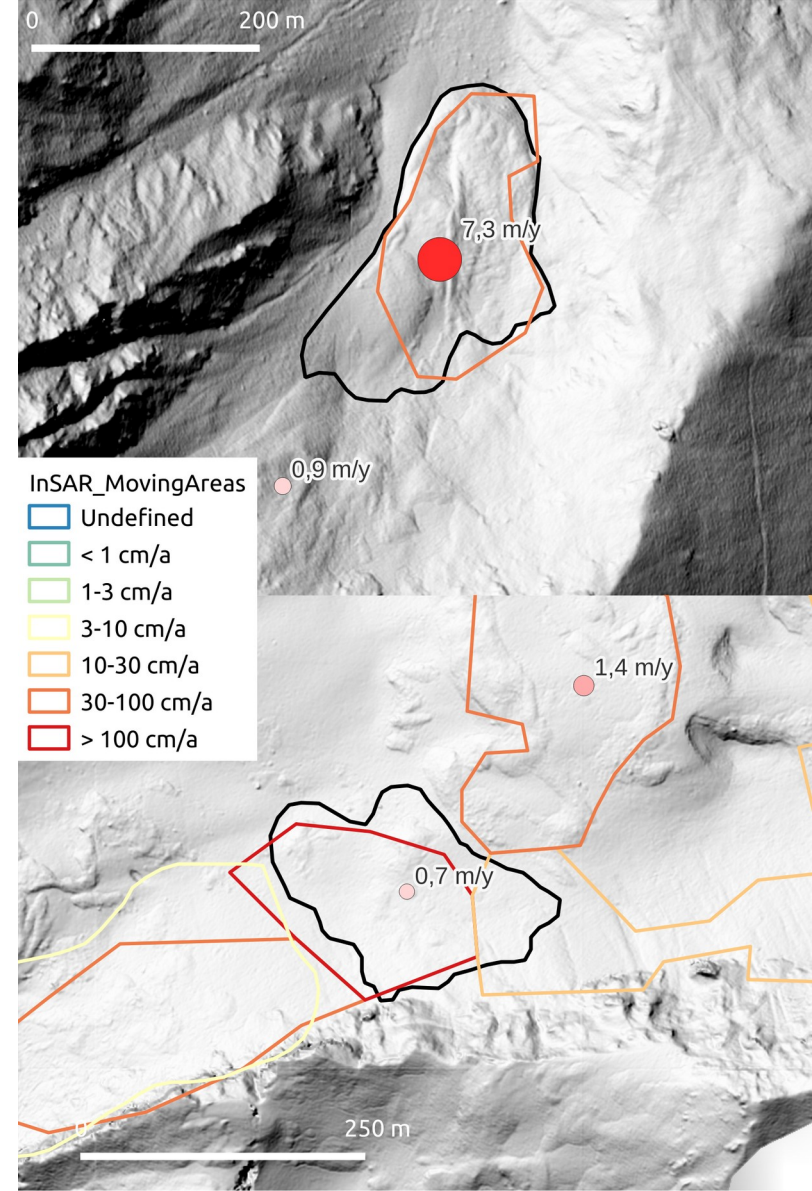
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Ex. of Relict RGs with InSAR KA > 10-30 cm/a (total = 26) →

Proportion of Velocity classes per classes of Activity ↓

	Active	Inactive	Relict
Undefined	4 %	1 %	13 %
< 1 cm/a	1 %	3 %	7 %
1-3 cm/a	2 %	1 %	7 %
3-10 cm/a	9 %	16 %	34 %
10-30 cm/a	24 %	30 %	19 %
30-100 cm/a	51 %	43 %	19 %
> 100 cm/a	10 %	6 %	0 %
Total nb	367	89	68

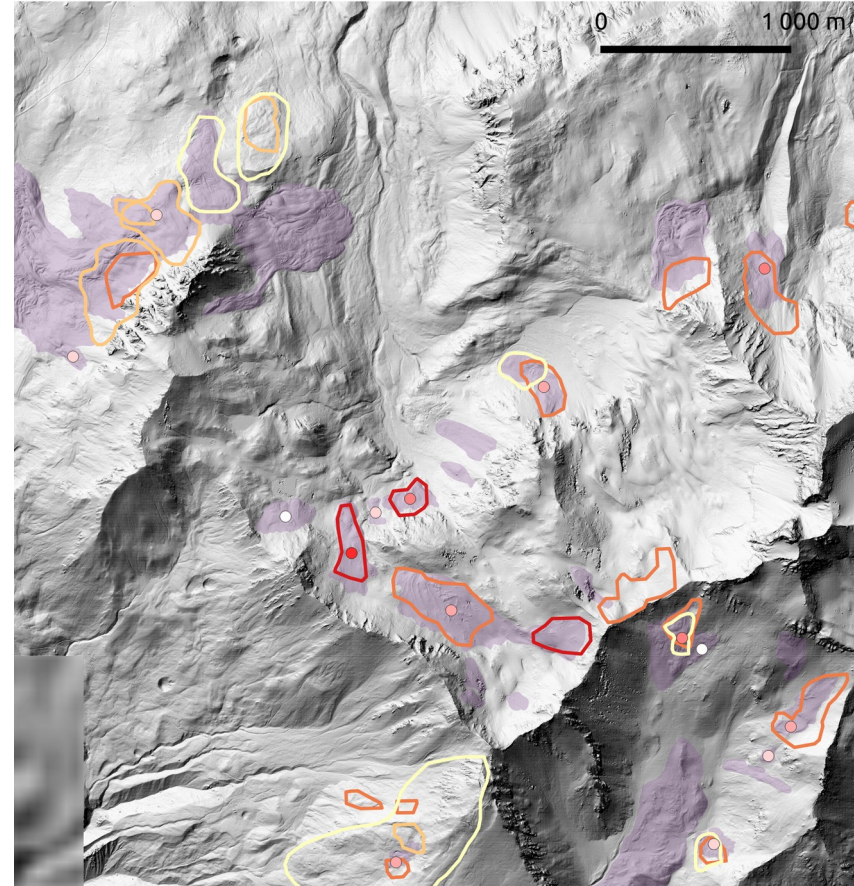
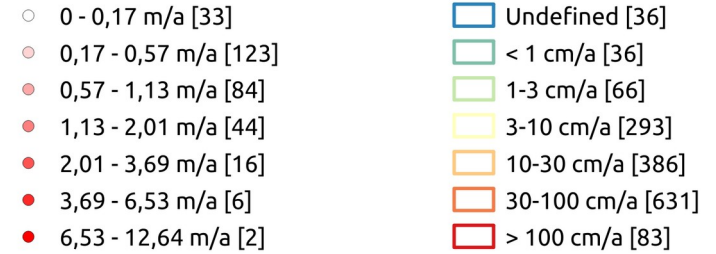


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Comparison between Optical and InSAR derived attributes

Feature tracking on optical images [308] InSAR_MovingAreas [1532]



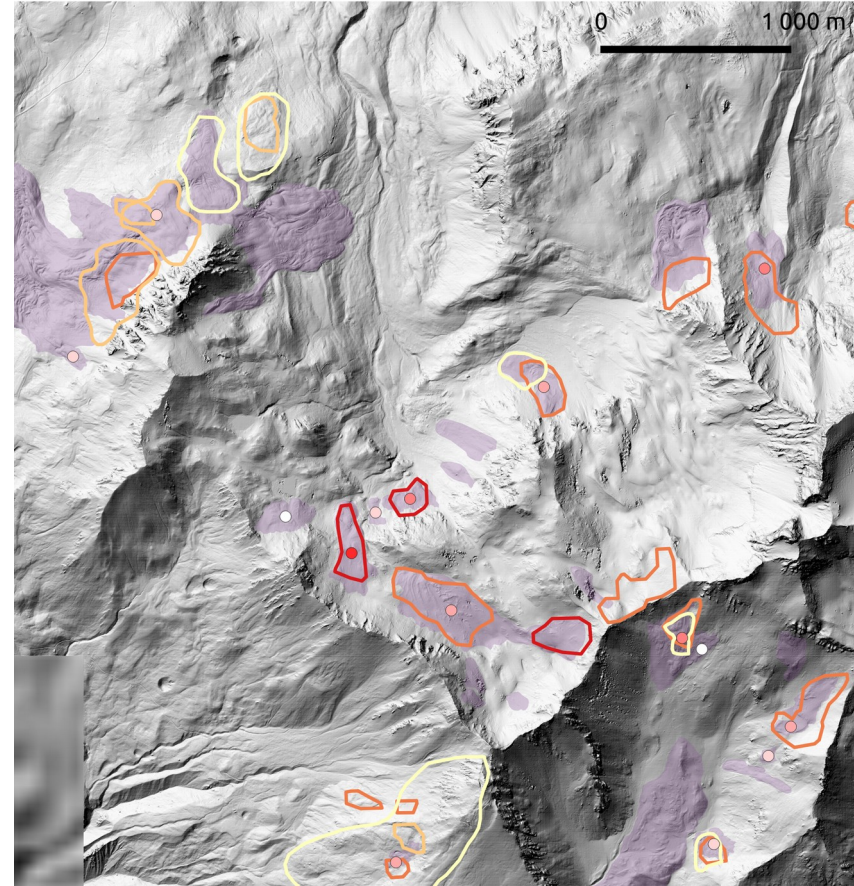
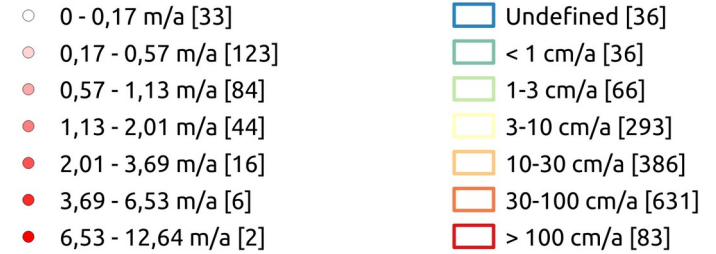
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- 437 RGs with InSAR
- 308 RGs with optical data

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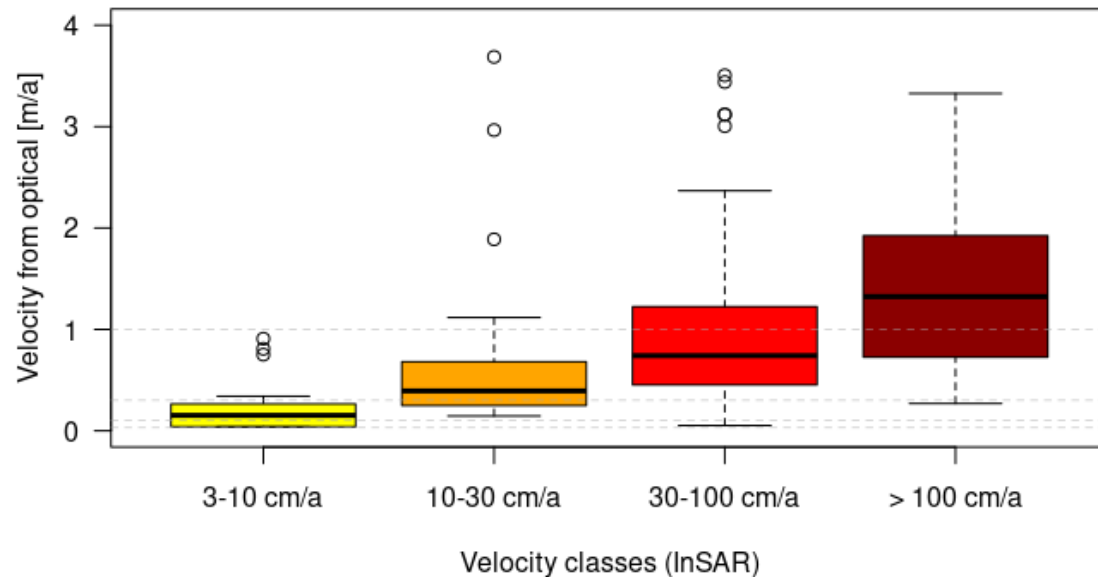


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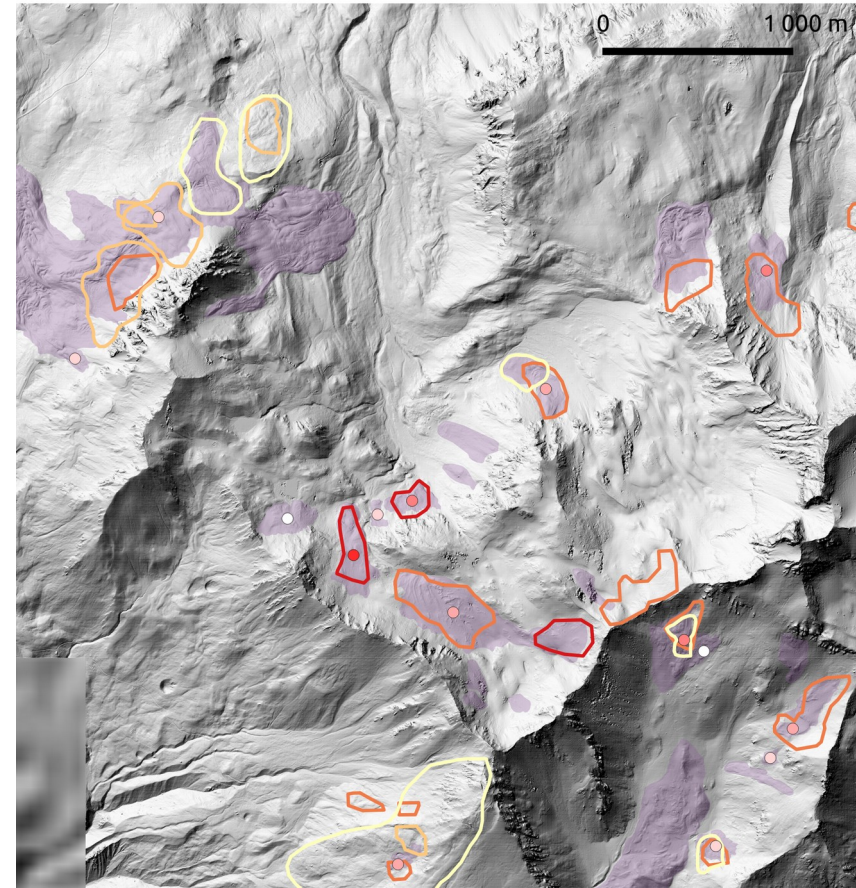
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- 437 RGs with InSAR
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- **202 RGs with both attributes**



Feature tracking on optical images [308] InSAR_MovingAreas [1532]

- 0 - 0,17 m/a [33]
- 0,17 - 0,57 m/a [123]
- 0,57 - 1,13 m/a [84]
- 1,13 - 2,01 m/a [44]
- 2,01 - 3,69 m/a [16]
- 3,69 - 6,53 m/a [6]
- 6,53 - 12,64 m/a [2]
- Undefined [36]
- < 1 cm/a [36]
- 1-3 cm/a [66]
- 3-10 cm/a [293]
- 10-30 cm/a [386]
- 30-100 cm/a [631]
- > 100 cm/a [83]



Conclusion

Main improvement of the revised FRoGI

- More than 350 new RGs from the revision process
- InSAR MA allowed the detection of ~40 % of the new RGs (for the operator that used InSAR)
- Rather good fit between InSAR velocity classes and velocities derived from optical feature tracking

But, still some (a lot of...) work to do...

- Terminate the ~20 % remaining
- Homogenize outlining (especially for rooting zone)
- Validate final geometry and activity classes, *for the RTM*
- Disseminate the FRoGI

... to reach the RGIK standard

- Read all the guidelines, and play with the RGIK-CCI+ exercises...
- Create the Primary markers
- Include Kinematic attribute

Thanks for your attention

