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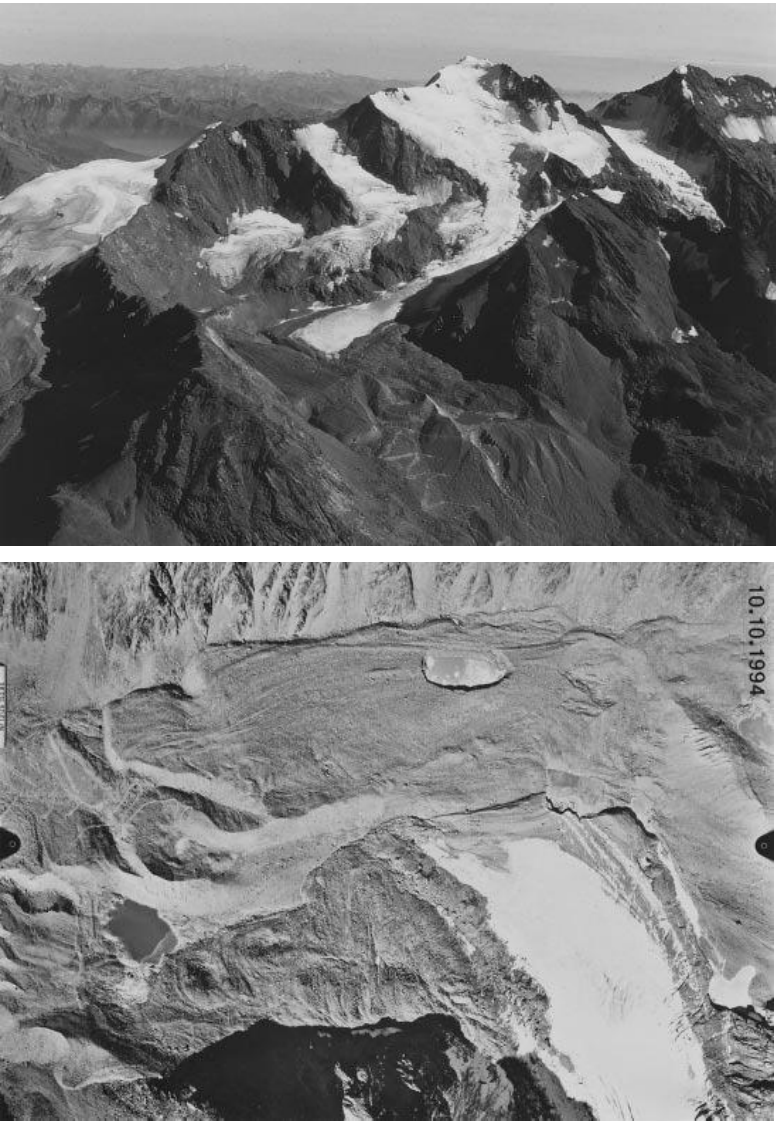
Glacier-permafrost interactions and GLOF's. Insights from 7 decades of kinematics and elevation changes in the Southern French Alps

Diego Cusicanqui[1,2,*],
Xavier Bodin[2], Antoine Rabatel[1], Pierre-Allain Duvillard[2,4], André Revil[2], Phillipe Schoeneich[3], Johan Berthet[4].

1 Univ. Grenoble Alpes, CNRS, IRD, Institut de Géosciences de l'Environnement (IGE, UMR 5001), F-38000 Grenoble, France.
2 Laboratoire EDYTEM, Université Savoie Mont-Blanc, CNRS, Le Bourget du Lac, France.
3 Université Grenoble Alpes, IUGA, PACTE, 38000 Grenoble, France.
4 Styx 4D, 73370 Le Bourget du Lac, France.

* Corresponding author: diego.cusicanqui@univ-grenoble-alpes.fr

I. Intro – Context

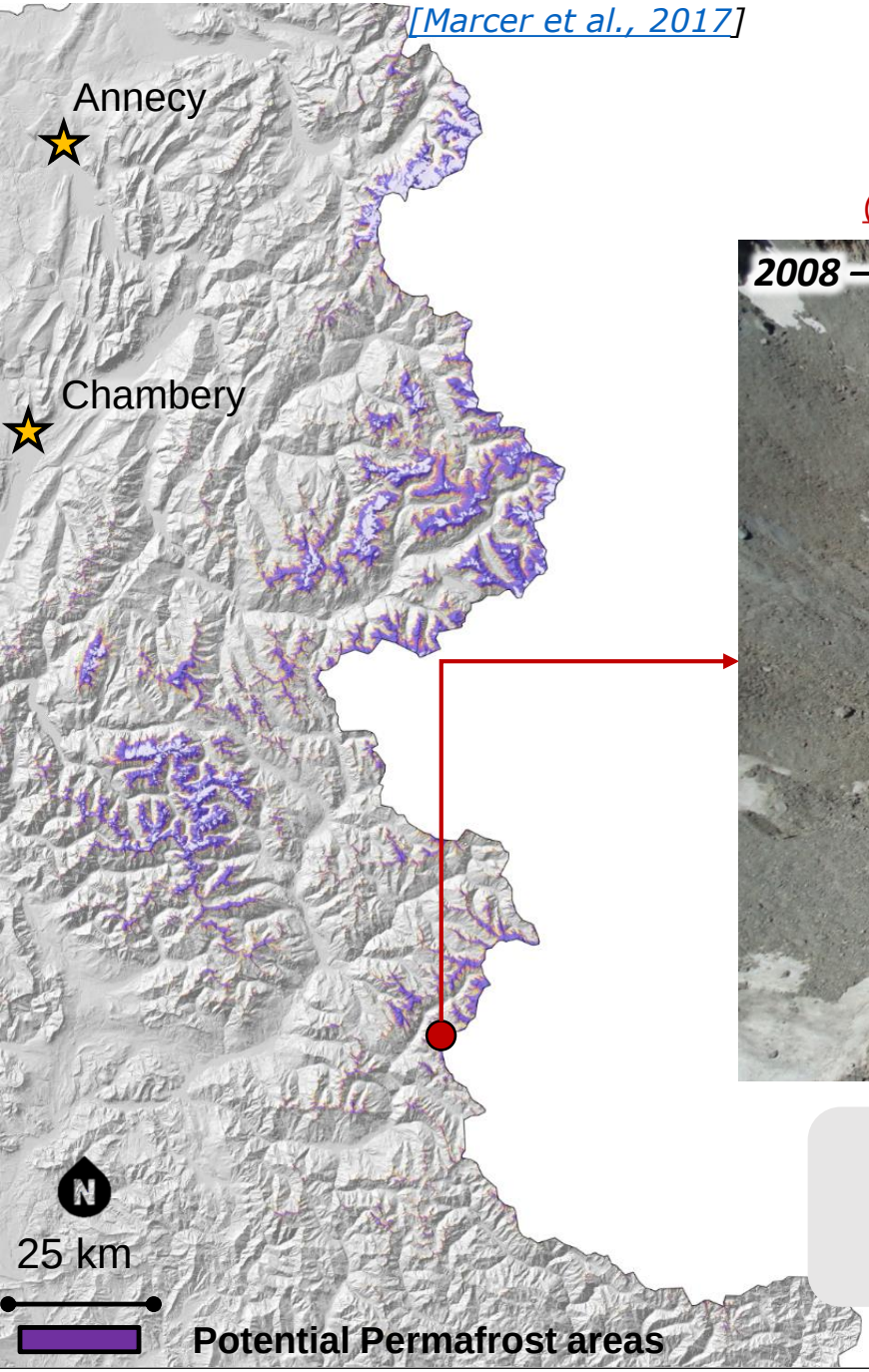


Gruben glacier and rock glacier, Switzerland, 1958 and 1994. *[Kääb et.al., 1997, Haeberli et. al., 2001]*

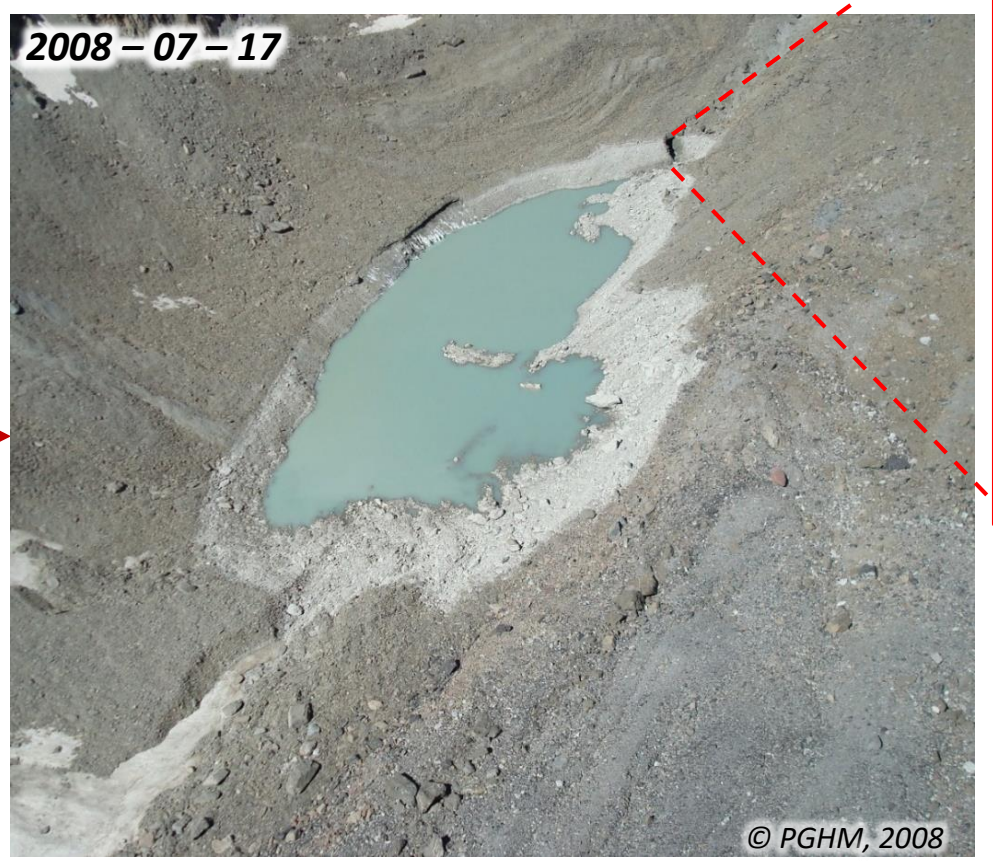
- Mountain cryosphere has been strongly impacted by global warming over the last three decades (i.e., accelerated rates of glacier retreat).
- This leads to mountain slopes instabilities amplifying existing hazards or even generating new ones.
- However, it depends on their physical characteristics and topographic configuration.

II. Study site – Chauvet system

[Marcer et al., 2017]

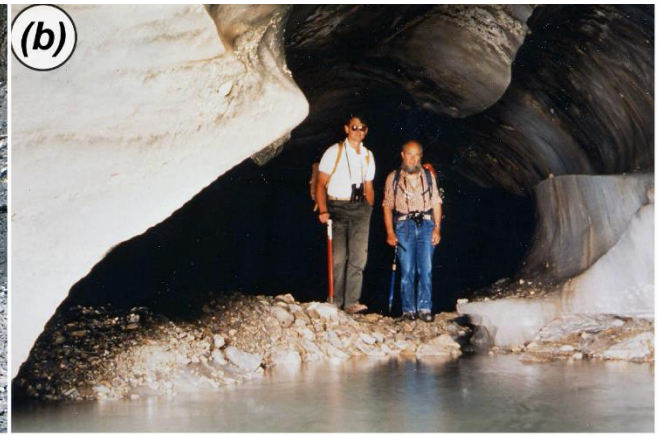


Haute Ubaye valley
(Lat: 44.55; Long: 6.84; Elev: 2,772 m a.s.l.)

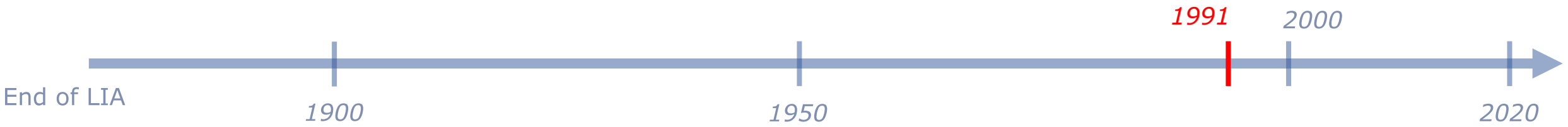


6 violent evacuation occurred (1936, 1956, 1970, 1991, 1997 et 2008)
[Cusicanqui et al., in review, ESPL]

II. Study site – Historical context



Drainage characteristics	
Lake volume	50 000 m^3
Draining time	1h30



II. Study sites – Historical context

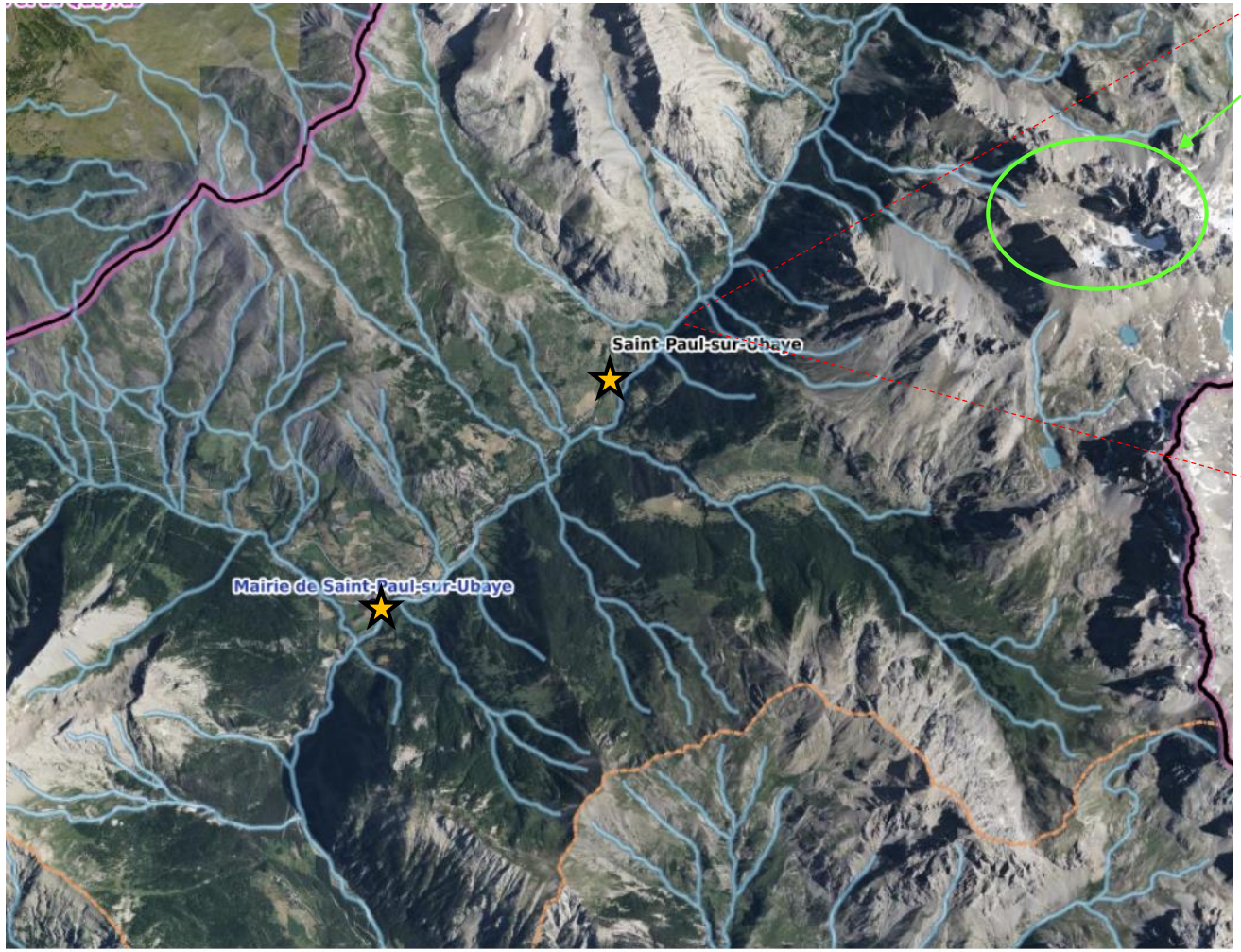
End of LIA — 1900 — 1950 — 2000 — 1997 — 2020

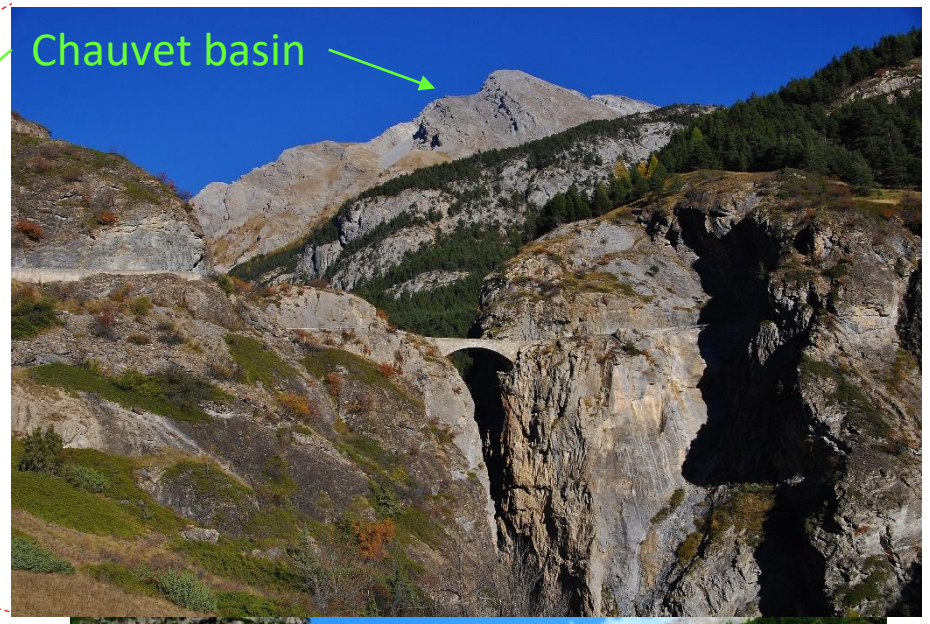
Drainage characteristics	
Lake volume	70-80 000 m^3
Draining time	3h

II. Study sites – Historical context

Drainage characteristics	
Lake volume	90 000 / 16 000 m^3
Draining time	4h30 / 4h

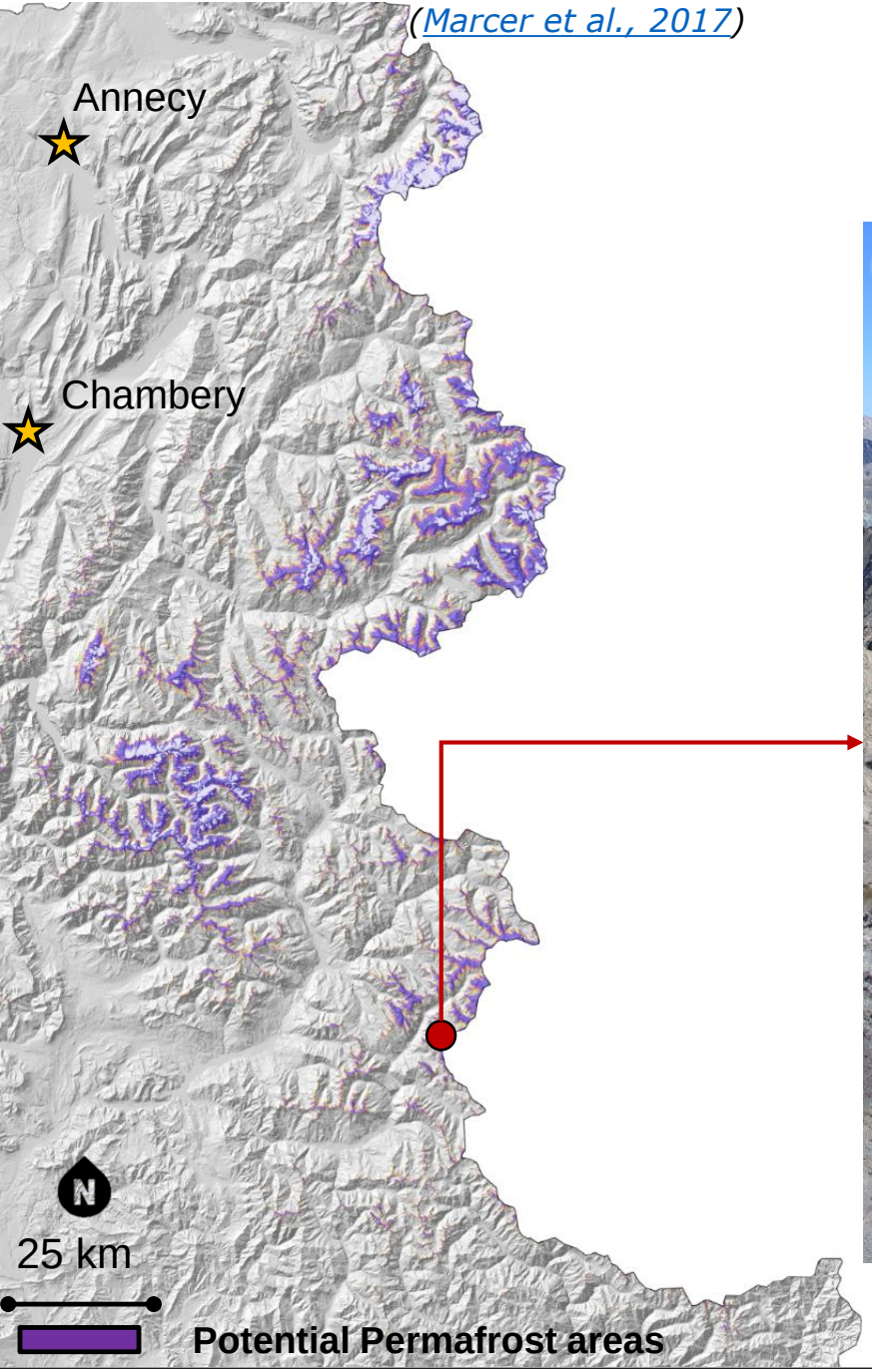
II. Study sites – Relevance





II. Study site – Plan chauvet system

(Marcer et al., 2017)



Haute Ubaye valley

(Lat: 44.55; Long: 6.84; Elev: 2,772 m a.s.l.)

Goal:

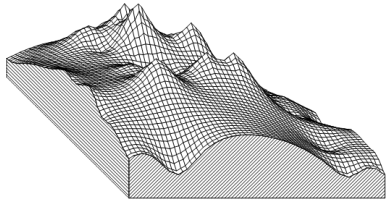
Explain which are the outburst floods origins?

6 violent evacuation occurred (1936, 1956, 1970, 1991, 1997 et 2008)
[Cusicanqui et al., in review, ESPL]

III. Processing – Data and methods

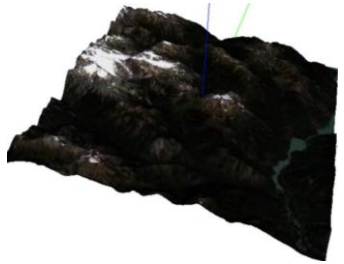
Photogrammetry 1950 - 2020

DSM's



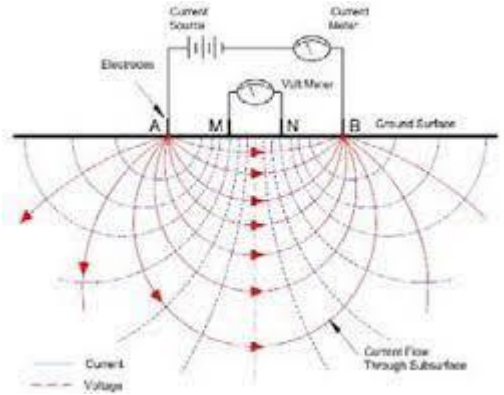
Surface elevation changes

Orthoimages

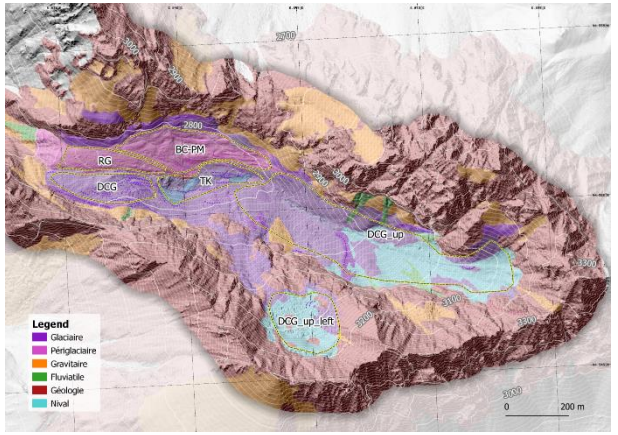


Feature tracking image correlation

Geophysics (ERT)

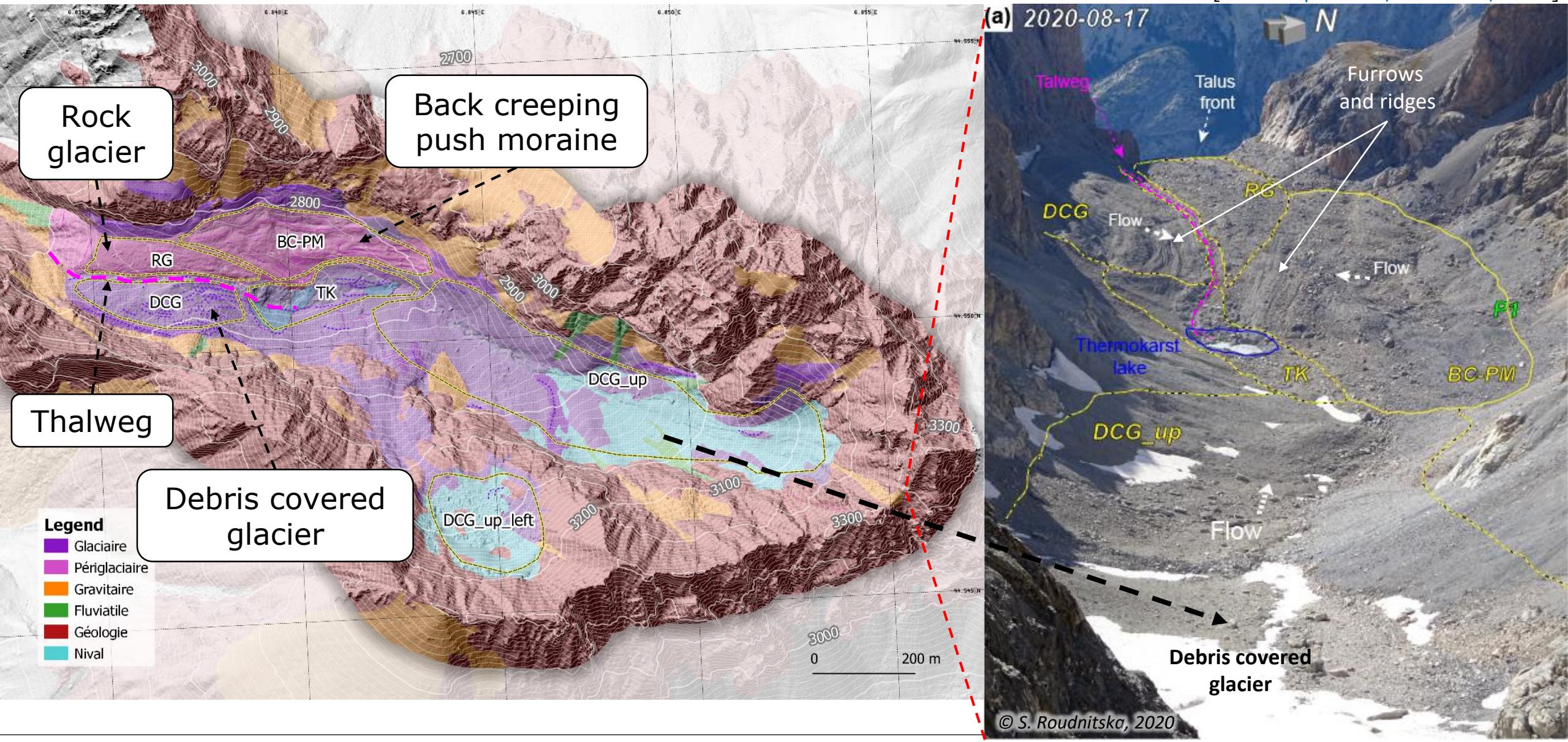


Geomorphology

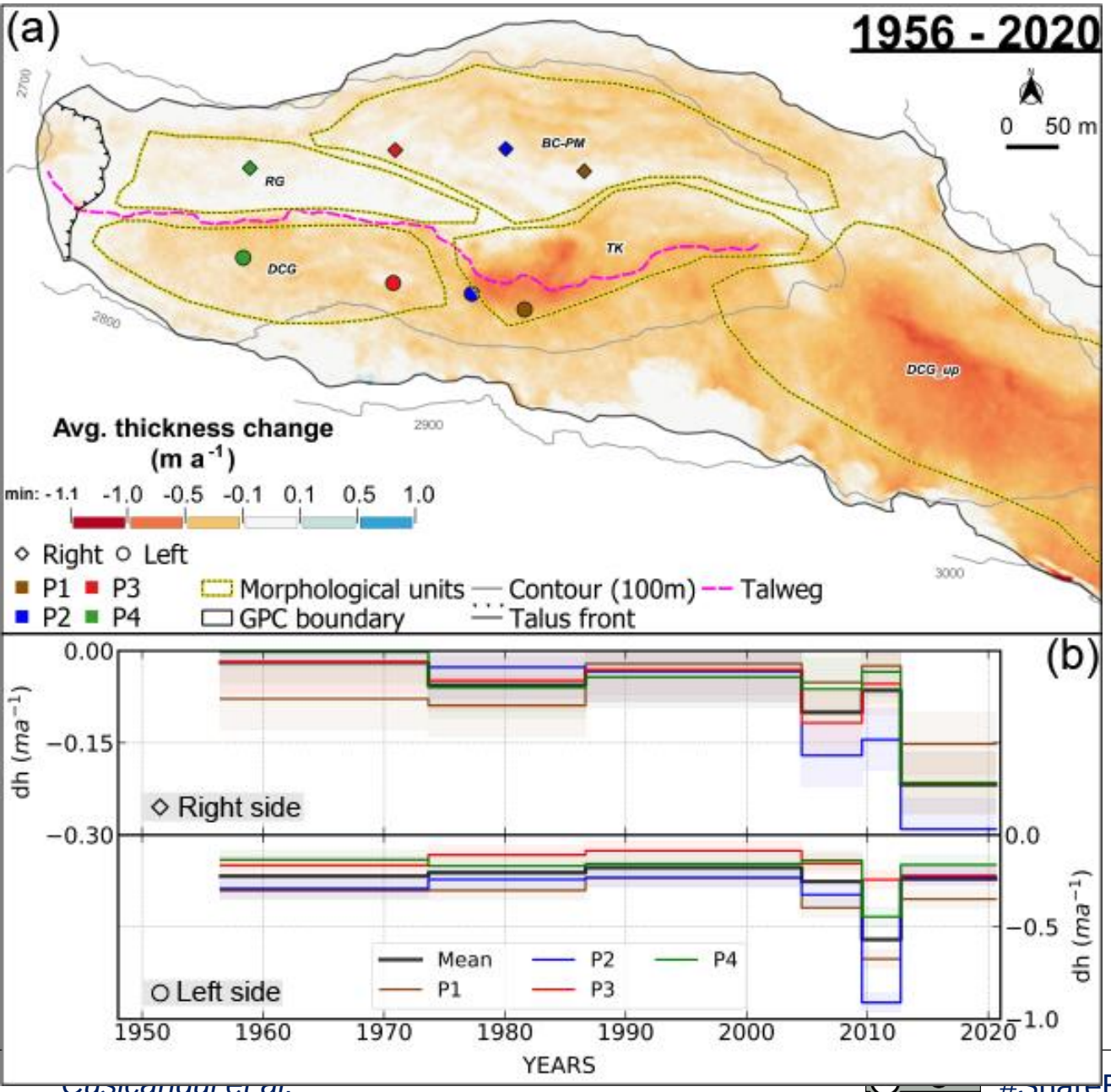


IV. Results – Geomorphology

[Cusicanqui et al., in review, ESPL]

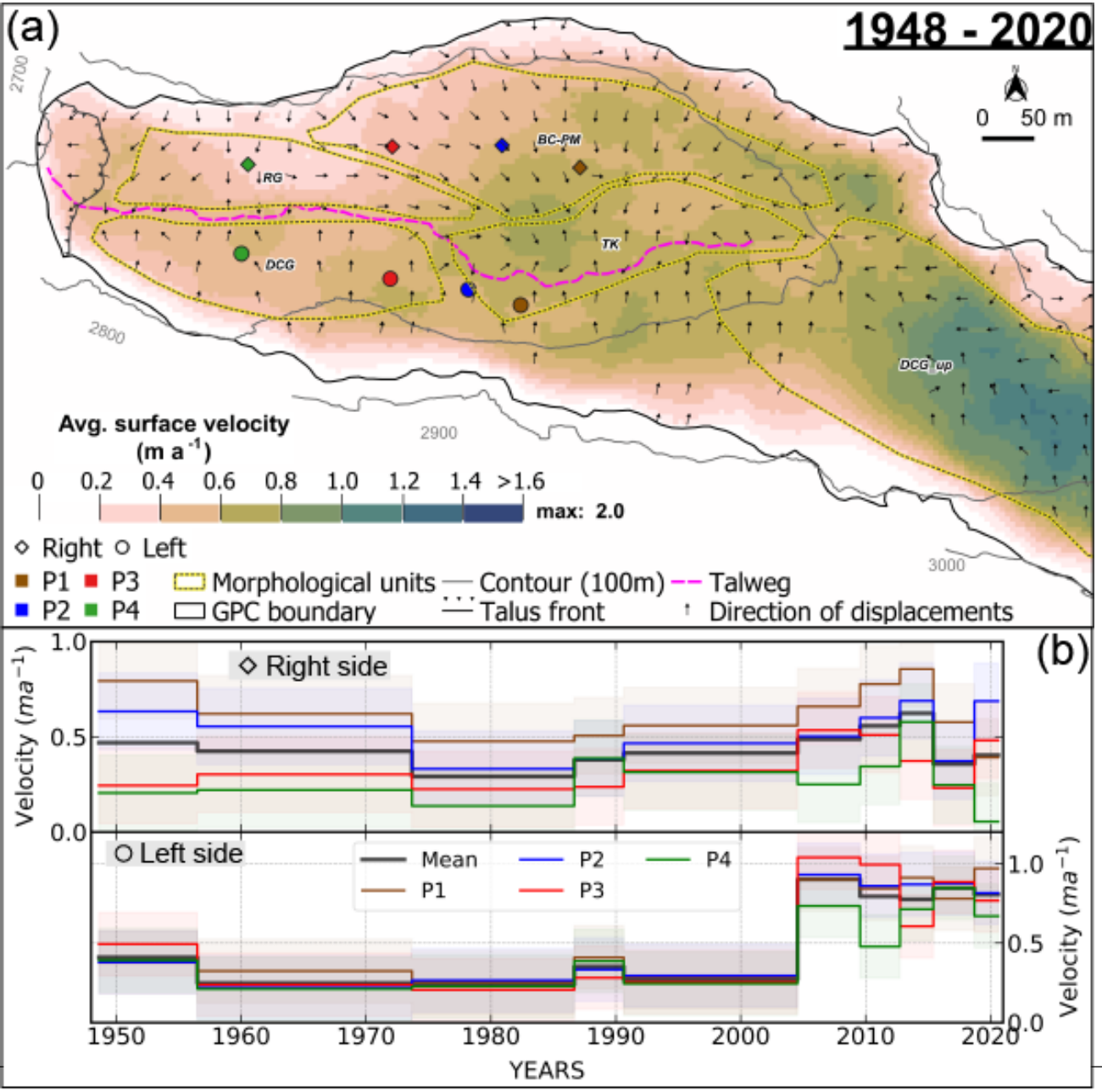


IV. Results – Thinning rates



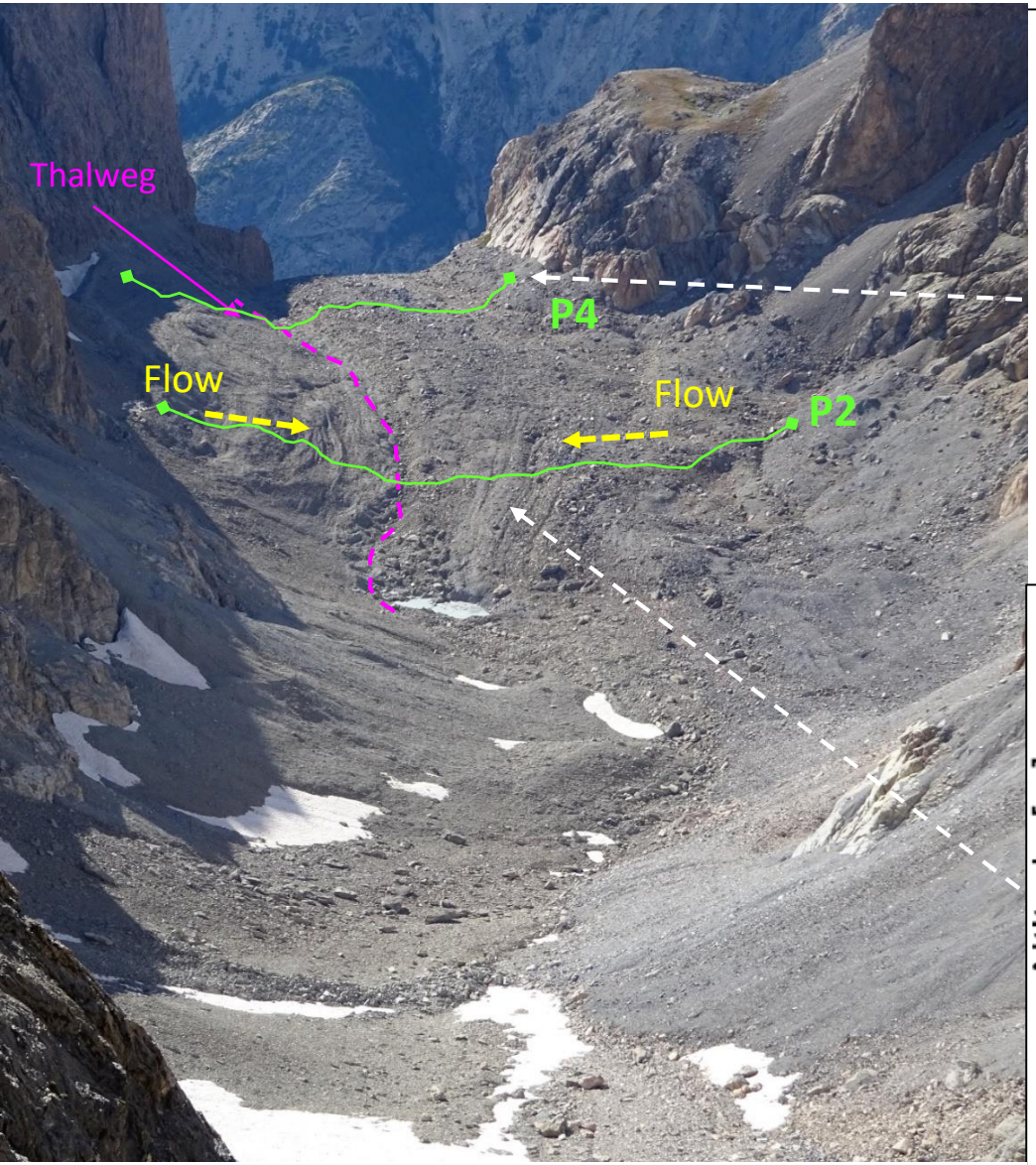
- Limited thickness change rates depending on the location over the landform.
- Most important thickness changes on debris cover glacier.

IV. Results – Surface velocities

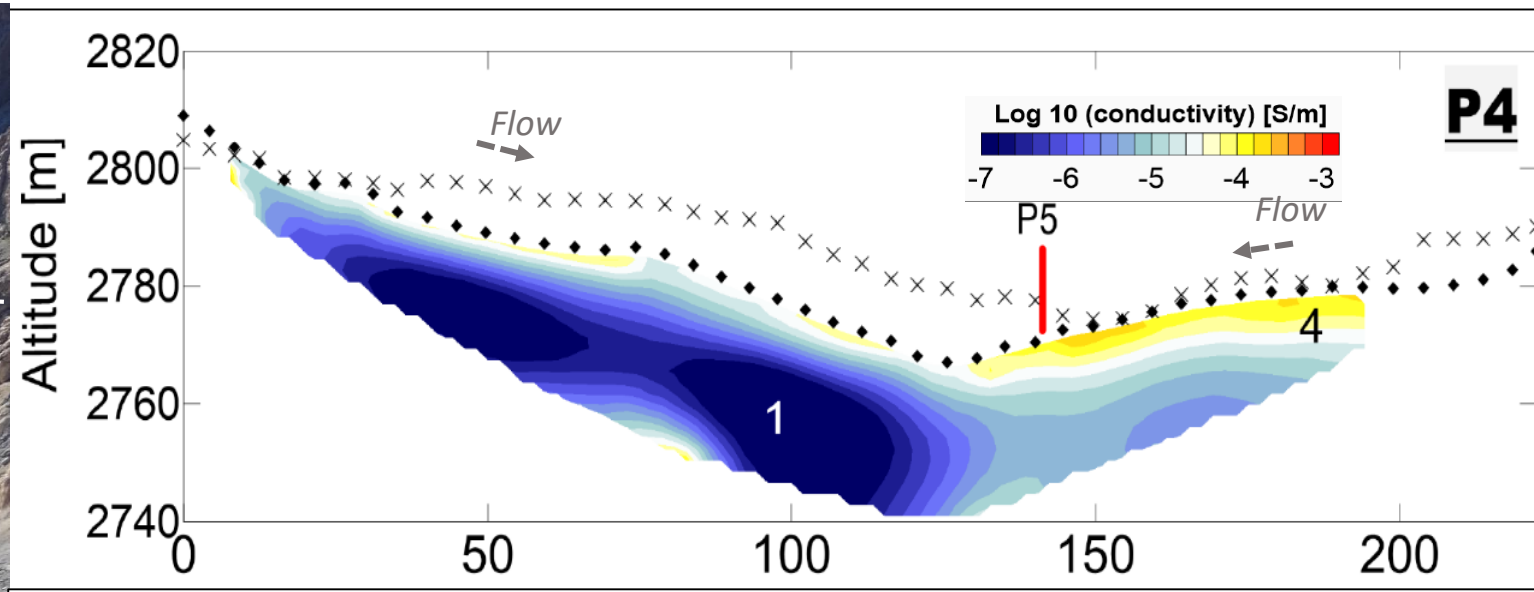


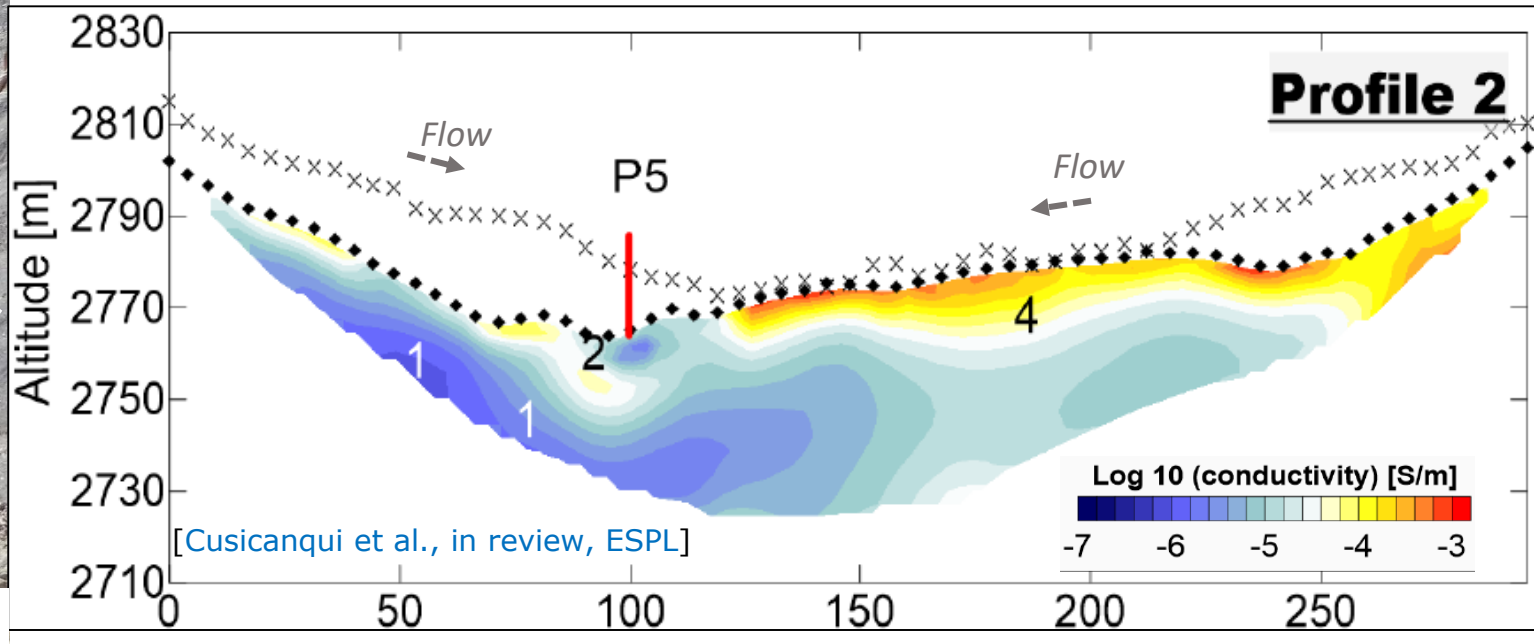
- Marked acceleration after 2000's.
- Right hand side shows almost constant velocity.
- Left hand side doubled in speed after 2000.

IV. Results – Internal structure



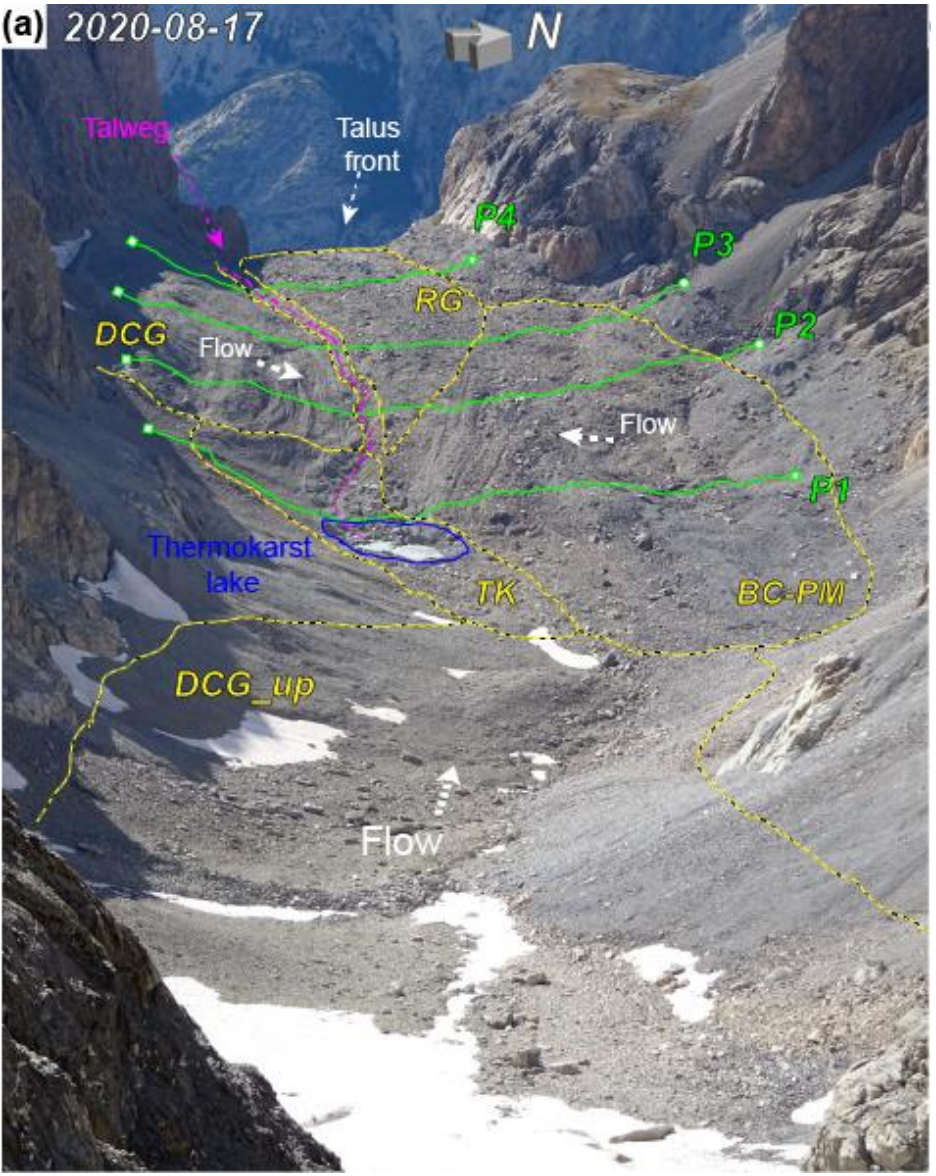
1 = massive ice; 2 = Water; 3 = Lake; 4 = Debris covered; 5 = Bedrock

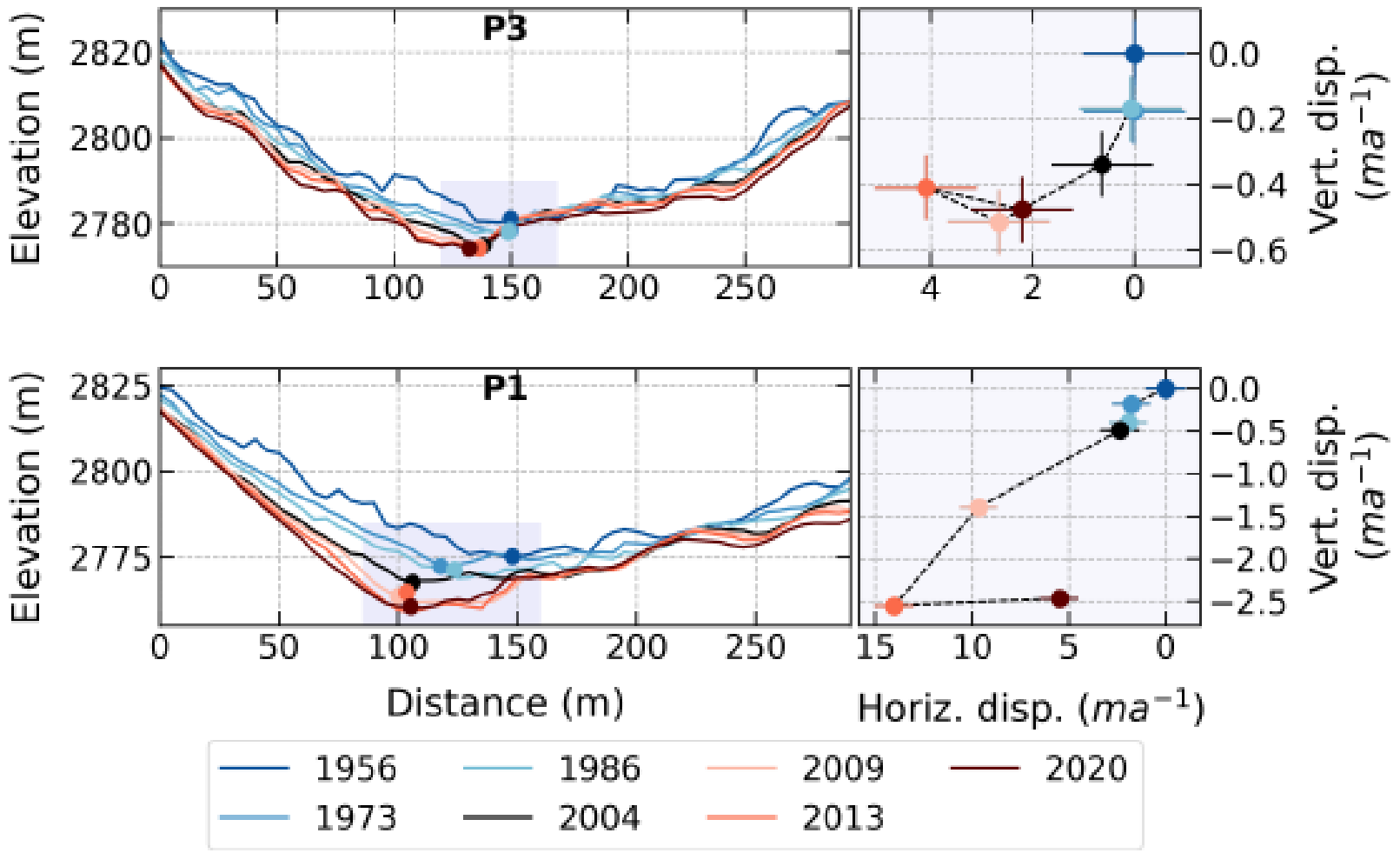




[Cusicanqui et al., in review, ESPL]

IV. Results – Thalweg dynamics



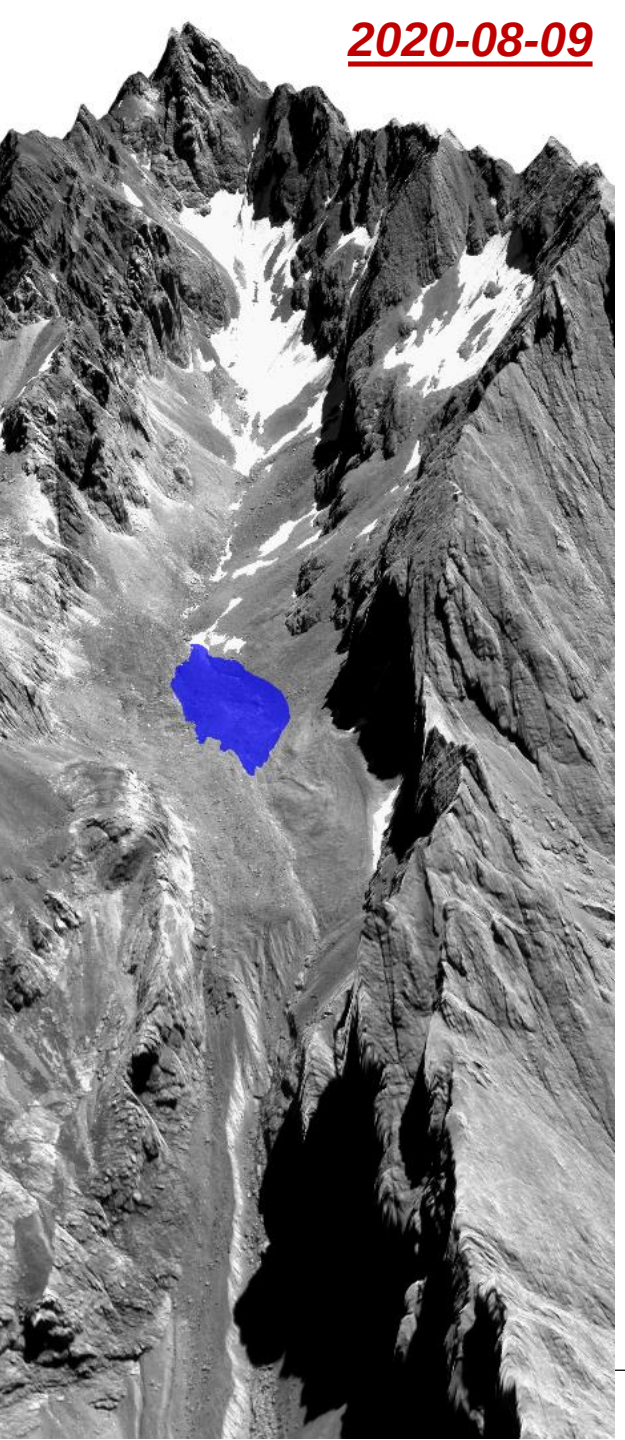


IV. Results – Discussion

Which are the outburst floods origins?

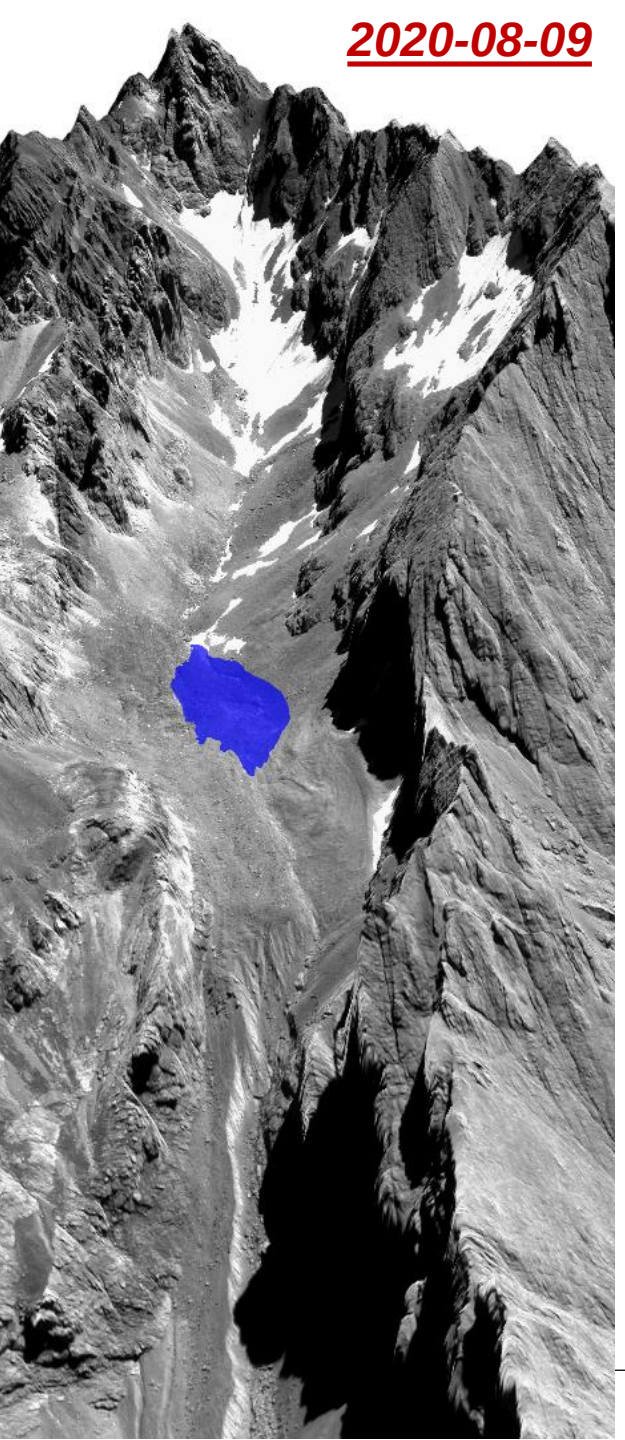
1. Hydro meteorological conditions
2. Closure of englacial conduit by creep
3. Internal thermal state
4. Karstic network
5. Topographic conditions

Currently, potential storage of **180 060 ± 418 m³** of water, which is two times higher than previous events.



V. Conclusions

- *Outburst floods origins **still unknown**. More data is required… However, we shed light on mechanisms that could likely control outburst floods .*
- *Complex spatio-temporal patterns and functional interactions between different landforms were evidenced.*
- *Doubling in flow velocity after 90's, coherent with displacements in European Alps.*
- *Given the current context, new outburst floods can took place in the future.*



Open questions

- *How to explain the presence of a rock glacier and debris covered glacier side by side?*
- *What about rock glacier origins?*


Thank you for your attention !
diego.cusicanqui@univ-grenoble-alpes.fr
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