



AGENCE
NATIONALE
DE LA COHÉSION
DES TERRITOIRES



Projet Science-Décision-Action

Réunion annuelle GIRN – SDA
Mardi 1er Décembre

PermaRisk



GIRN
Alpes



Ubaye©Chauvet



Philippe Schoeneich – Responsable scientifique

		Volets thématiques		
		Glaciers rocheux	Thermokarst	Infrastructures sur permafrost
Approches méthodologiques	Modélisation	Action 1.1 : Carte du permafrost à l'échelle des Alpes françaises		
			Action 1.2 : Carte des zones potentielles de thermokarst	
	Inventaires d'objets	Action 2.1 : Inventaire des glaciers rocheux	Action 2.2 : Inventaire des lacs et phénomènes thermokarstiques	Action 2.3 : Inventaire des infrastructures sur permafrost
	Evaluation	Action 3.1 : Sensibilité des glaciers rocheux au changement climatique	Action 3.2 : Dangerosité des lacs thermokarstiques	Action 3.3 : Quantification des aléas et de la vulnérabilité des infrastructures (indice de risque)
	Etudes de cas	Action 4.1 : Glaciers rocheux : Monestier/Laurichard Les Houches/Dérochoir Lanslevillard/Col du Lou Signal de l'Iseran Roche Brune ...	Action 4.2 : Lacs : Tignes Lac Chauvet	Action 4.3 : Infrastructures : Val Thorens Grands Montets Cosmiques Val d'Isère ...
	Mesures de gestion	Action 5.1 : Suivi et surveillance	Action 5.2 : Dispositif de signallement et d'alerte	Action 5.3 : Suivi Mesures préventives et adaptatives (solutions géotechniques)
		Action 5.4 : Gestion intégrée : information, sensibilisation, formation, outils d'aide à la décision Intégration des risques liés au permafrost dans la gestion générale des risques naturels		
Communication		Actions 6.1 à 6.3 : Diffusion des résultats Action 6.4 : session spéciale EUCOP5 Action 6.5 : Vulgarisation Action 6.6 : Film		

3 volets thématiques

Des données couvrant l'ensemble des Alpes françaises

Des études cas localisées

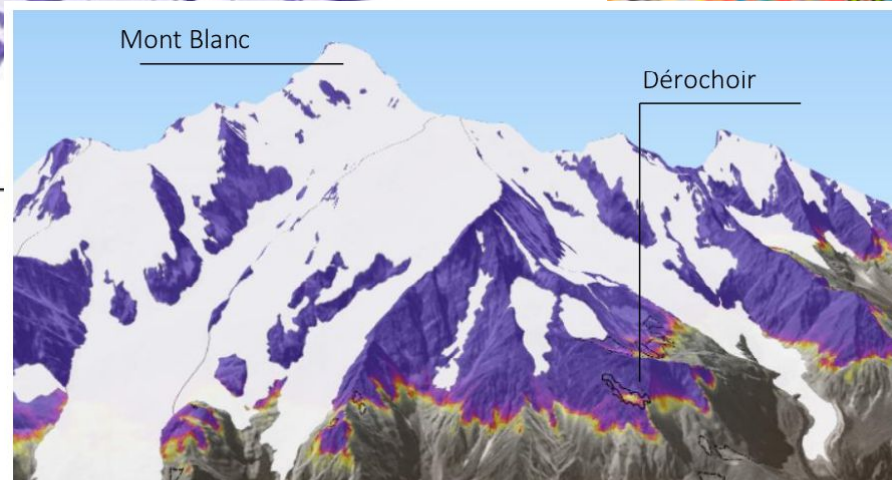
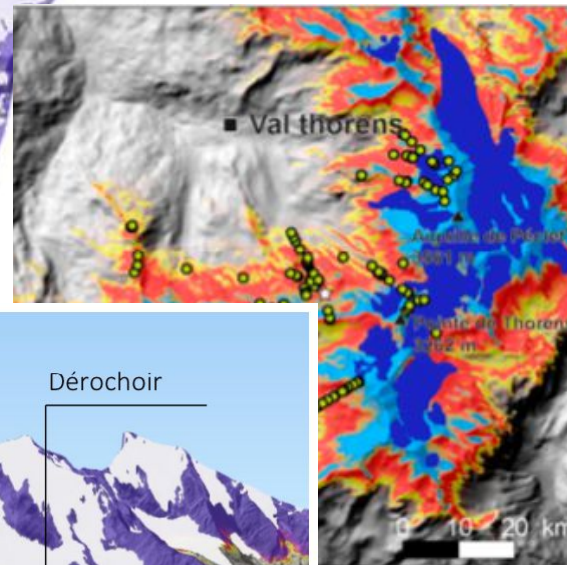
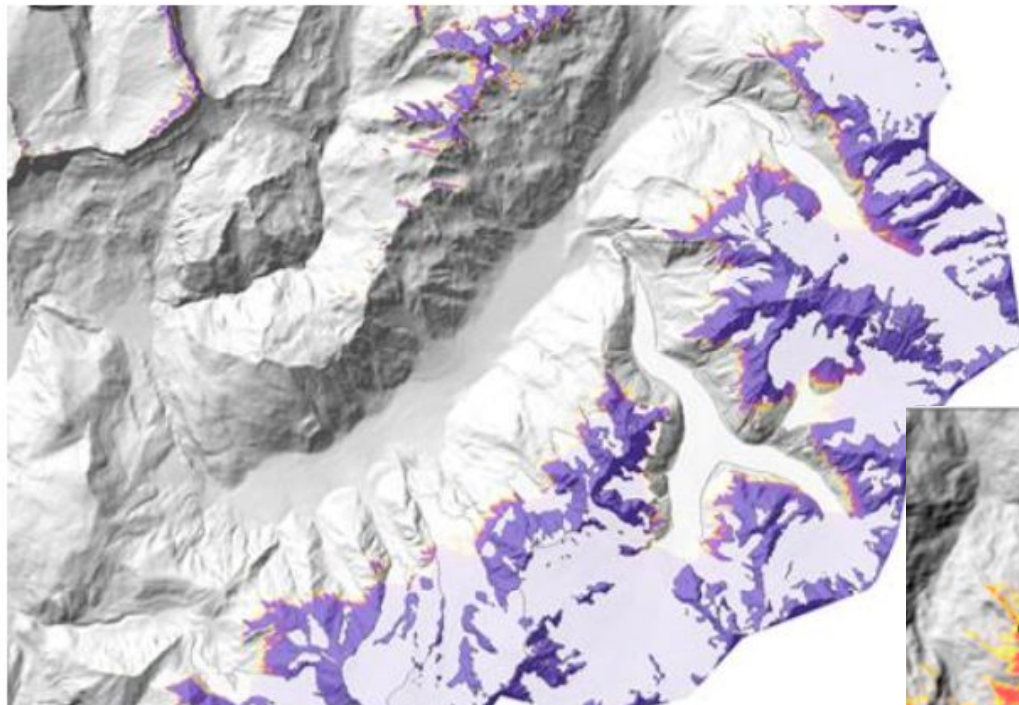
Des recommandations de gestion

De la diffusion de connaissances

Action 1.1 – Carte du permafrost des Alpes françaises

Carte de probabilité de distribution du permafrost = permafrost existant modélisé à partir de l'inventaire des glaciers rocheux

Carte de susceptibilité à la fonte = déséquilibre par rapport aux conditions climatiques actuelles



Permafrost Favorability Index: Spatial Modeling in the French Alps Using a Rock Glacier Inventory

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OPEN ACCESS

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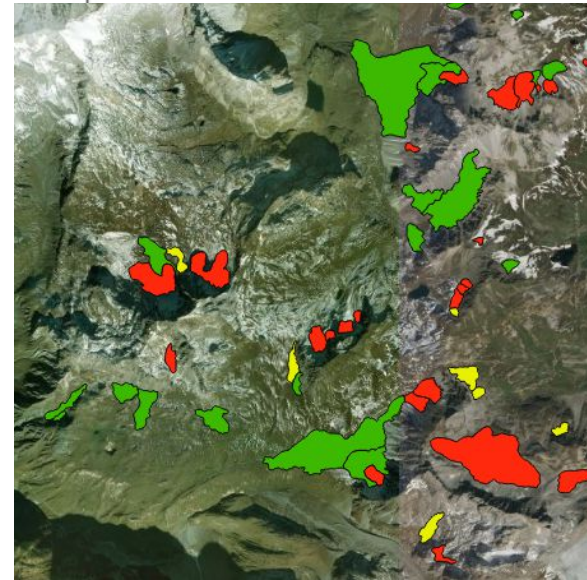
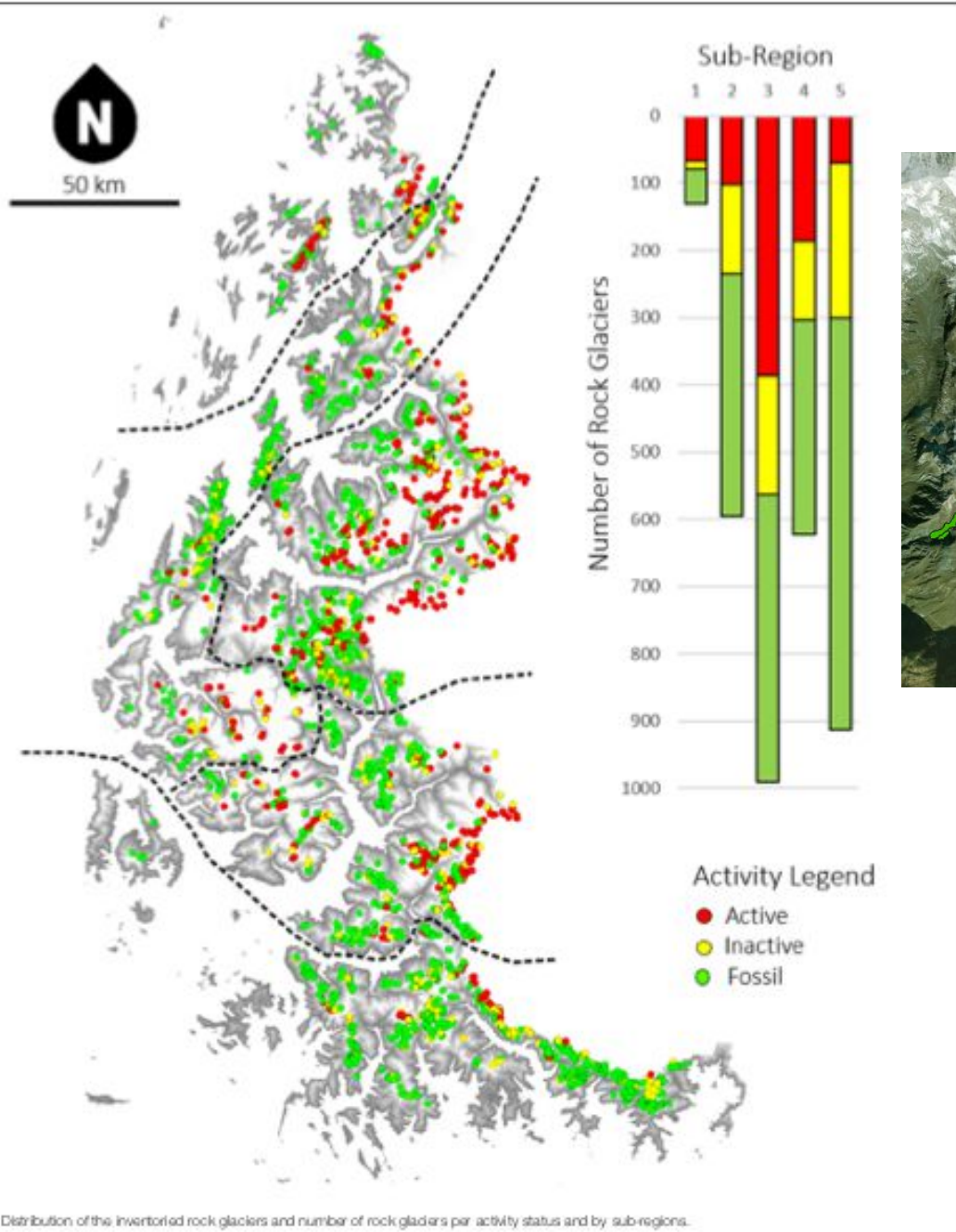
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Specialty section:
This article was submitted to
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a section of the journal
Frontiers in Earth Science

In the present study we used the first rock glacier inventory for the entire French Alps to model spatial permafrost distribution in the region. Climatic and topographic data evaluated at the rock glacier locations were used as predictor variables in a Generalized Linear Model. Model performances are strong, suggesting that, in agreement with several previous studies, this methodology is able to model accurately rock glacier distribution. A methodology to estimate model uncertainties is proposed, revealing that the subjectivity in the interpretation of rock glacier activity and contours may substantially bias the model. The model highlights a North-South trend in the regional pattern of permafrost distribution which is attributed to the climatic influences of the Atlantic and Mediterranean climates. Further analysis suggest that lower amounts of precipitation in the early winter and a thinner snow cover, as typically found in the Mediterranean area, could contribute to the existence of permafrost at higher temperatures compared to the Northern Alps. A comparison with the Alpine Permafrost Index Map (APIM) shows no major differences with our model, highlighting the very good predictive power of the APIM despite its tendency to slightly overestimate permafrost extension with respect to our database. The use of rock glaciers as indicators of permafrost existence despite their time response to climate change is discussed and an interpretation key is proposed in order to ensure the proper use of the model for research as well as for operational purposes.

Keywords: permafrost modeling, French Alps, mountain permafrost, rock glaciers, statistical modeling

Action 2.1 – Inventaire des glaciers rocheux



Inventaire des glaciers rocheux RTM

3260 glaciers rocheux. Dont :

814 actifs

671 inactifs

3261 fossiles

Ré-évaluation de l'activité par analyse diachronique d'images et par InSAR

Fiche technique n° 3 – Inventaire des glaciers rocheux

Mode d'emploi N°3

1) Insertion d'une couche au format Shapefile (Vecteur) dans un logiciel SIG

Saisie des métadonnées d'une donnée géographique

Export XML 19139

Description

* la saisie des informations marquées d'un astérisque est obligatoire dans le cas d'une donnée concernée par INSPIRE

*Intitulé de la ressource :

*Résumé de la ressource :

*Identificateur de ressource unique :

*Catégorie thématique : (1) Environnement (2) Information géo-scientifique (3) Altitude

Définition INSPIRE

[Obligatoire] Nom caractéristique et souvent unique sous lequel la ressource est connue. Exemple : Plan de Prévention du Risque Inondation (PPRI) de Paris

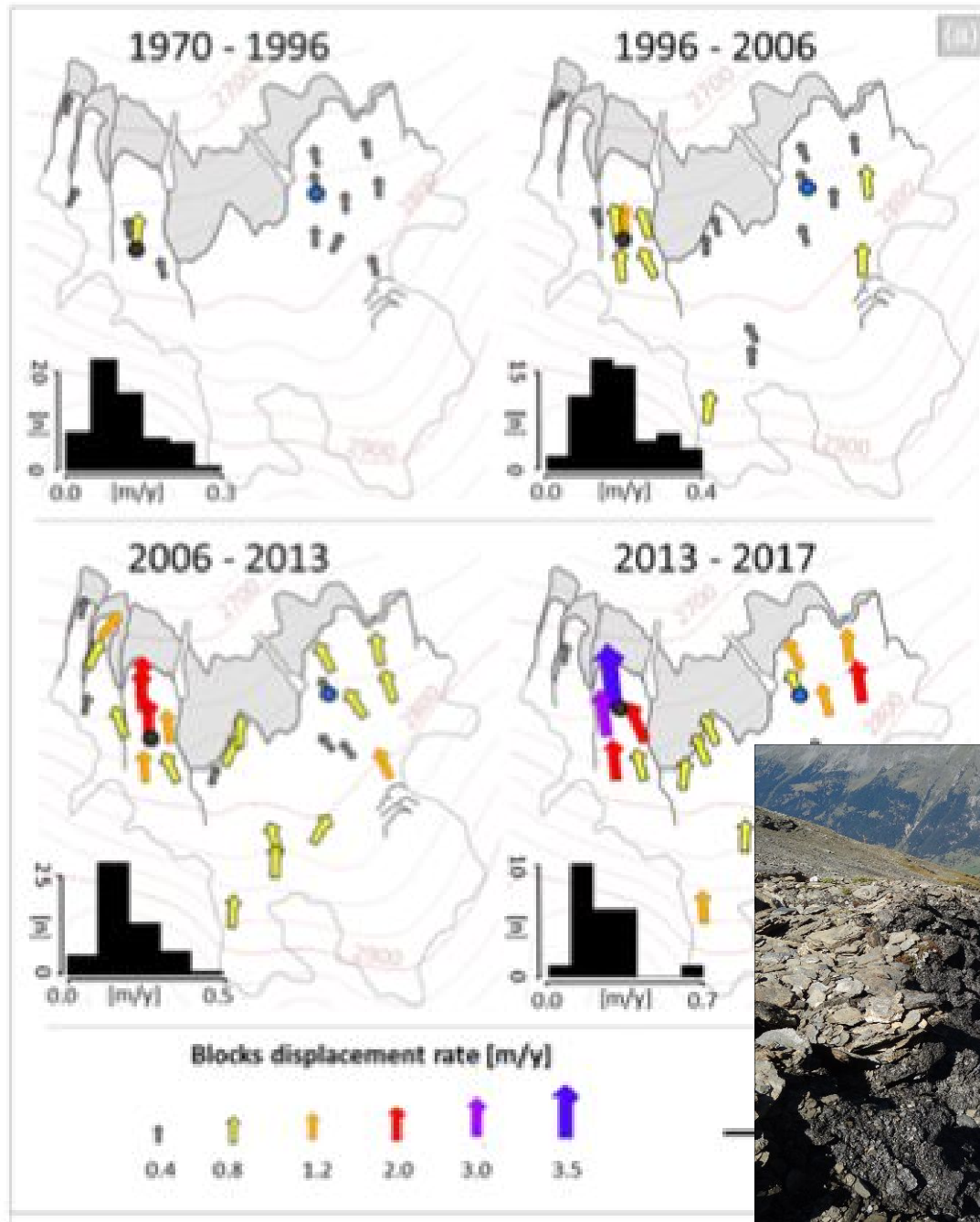
[Obligatoire] Bref résumé narratif du contenu de la ressource. Exemple : PPR178_Mauvoisin_Aisne est la représentation numérique des aléas hydrauliques du plan de prévention des risques d'inondation (PPR réglementaire).

[Obligatoire] Une valeur identifiant la ressource de manière unique. Exemples : Recommandation A : http://www.ign.fr/bloc_identifiant_le_jeu_de_donnees ; Recommandation B : fr-numéro_SIREN-bloc_identifiant Voir guide de recommandation du CNIG

[Obligatoire] Système de classification de haut niveau qui permet de regrouper et de chercher par thème les ressources de données Exemple : Cadastre, aménagement

Action 4.1 - Etude de cas de glaciers rocheux

Lautaret - Laurichard
Lanslevillard – Col du Loup
Les Houches – Dérochoir
Termignon – Pierre Brune



Received 19 October 2018 | Revised 29 August 2019 | Accepted: 26 September 2019
DOI: 10.1002/ppp.2035

RESEARCH ARTICLE

Investigating the slope failures at the Lou rock glacier front, French Alps

Marco Marcer^{1,2} | Steffen Ringsø Nielsen^{1,3} | Charles Ribeyre¹ | Mario Kummert⁴ |
Pierre-Allain Duvillard^{1,2,5} | Philippe Schoeneich¹ | Xavier Bodin² | Kim Genuite²

¹Institut d'Urbanisme et Géographie Alpine, Univ. Grenoble Alpes, PACTE, 38000, Grenoble, France

²CNRS, Univ. Savoie Mont-Blanc, UMR CNRS 5204, EDYTEM, 73370, Le Bourget du Lac, France

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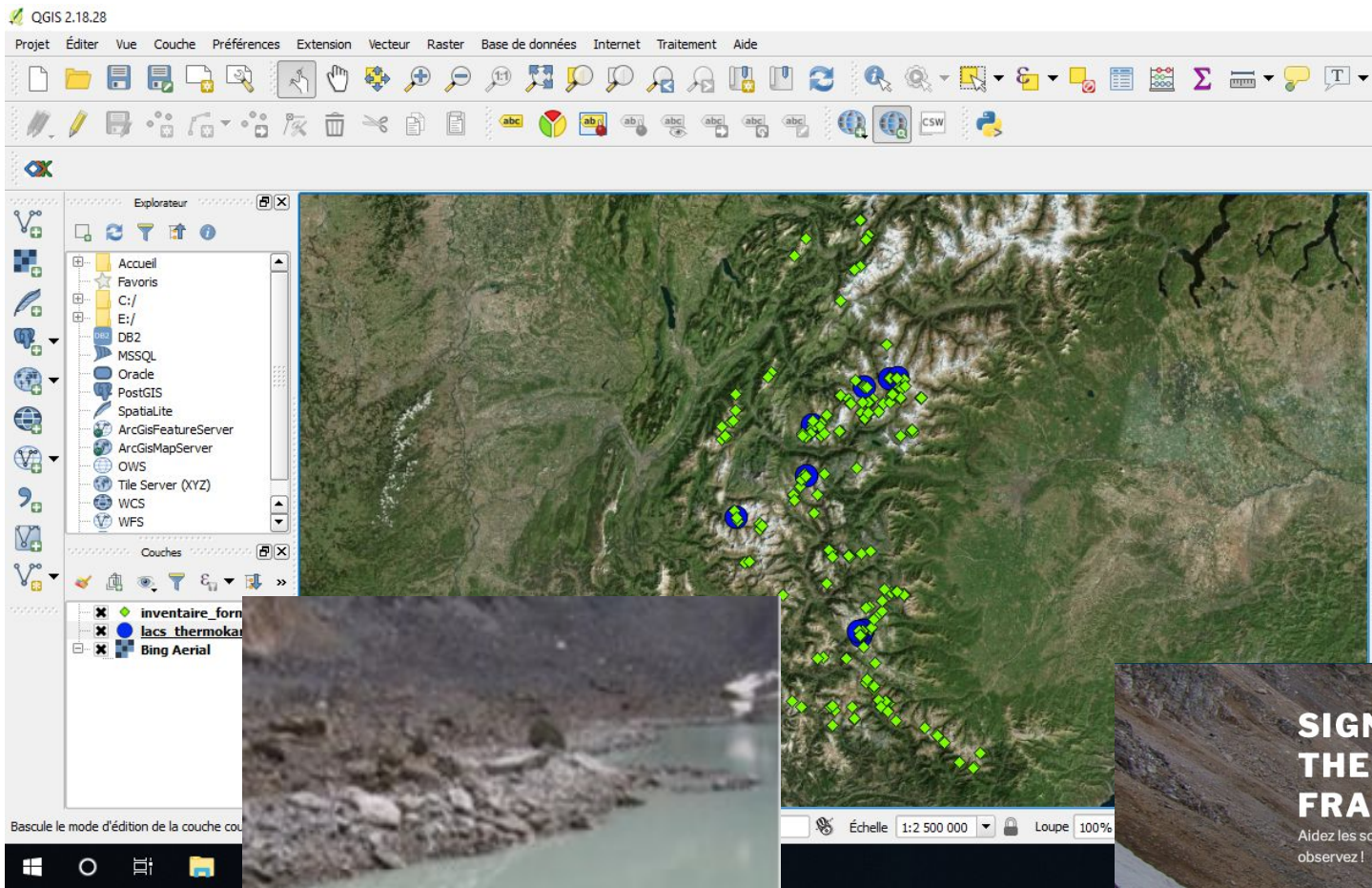
European Regional Development Fund, Grant/Award Number: POIA PA0004100; Lanslevillard Commune

Abstract

On August 14th 2015 a large debris flow initiated by the occurrence of two slope failures at the front of the Lou rock glacier flooded part of the town of Lanslevillard, France. The present study aims to understand the meteorological and geomorphological context that led to these failures. Investigations were conducted by combining meteorological data, surface movements, and geophysical transects. The analysis indicates that the Lou rock glacier is directly connected to an active torrential channel and has a natural predisposition to frontal failure due to the steepness of its front. The slope failures were triggered after a heat wave followed by a three-week period of almost continuous rainfall. Water flowing on top of the permafrost table was observed in the two head scarps, suggesting that regressive erosion consecutive to this concentrated subsurface water flow triggered the failures. For one of the slides, traces of previous failures were observable on historical aerial imagery dating back to the 1950's, while the second slide corresponded to a novel event and developed on the frontal slope of a fast-moving and destabilized rock glacier lobe. We also discuss the increase in local predisposition to failure related to the remarkable morphological modifications such as frontal advance and development of surface cracks associated with the lobe destabilization.

KEYWORDS

destabilization, natural hazard, Rock glacier, slope failure



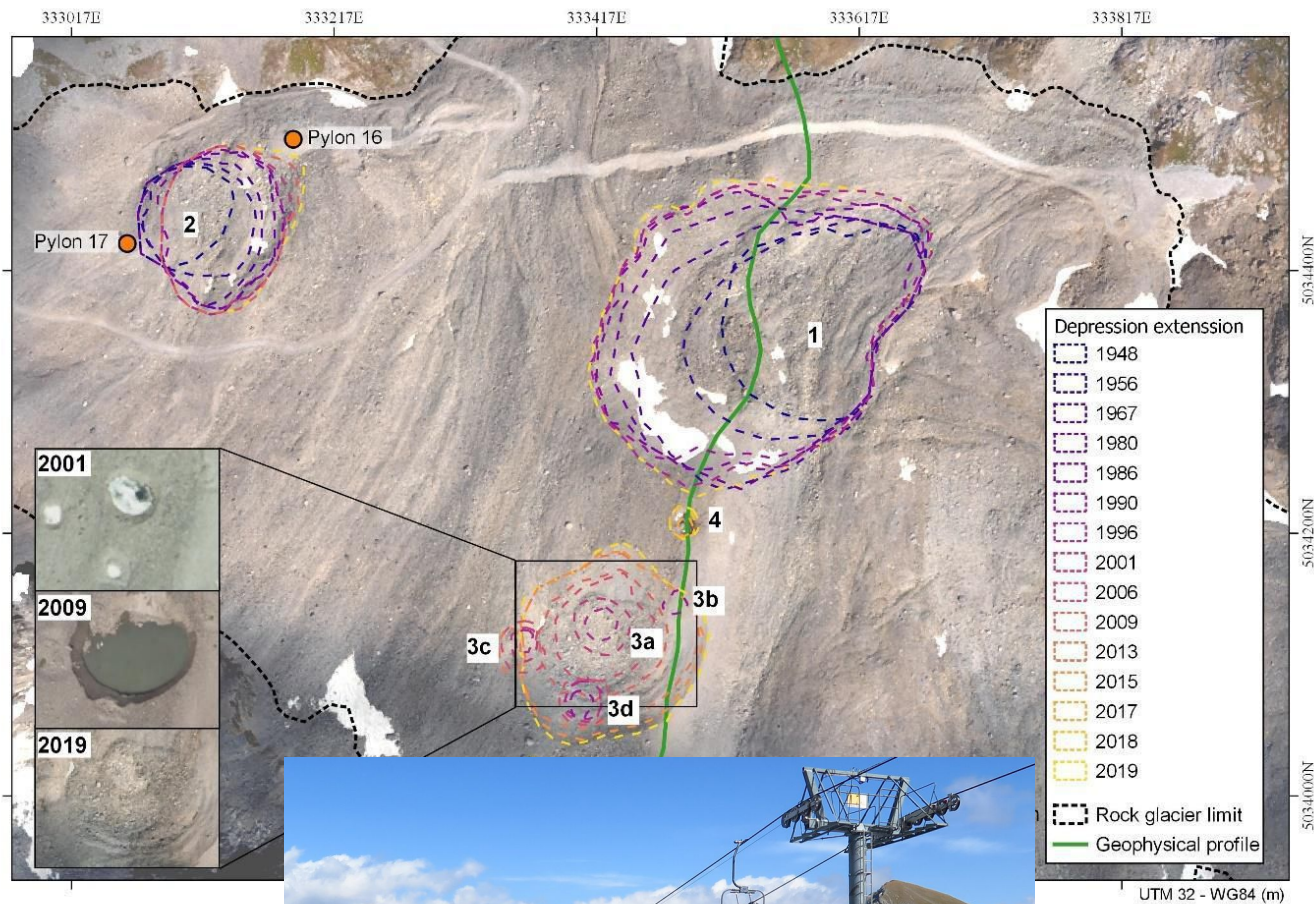
Action 2.2 – Inventaire des formes thermokarstiques

Inventaire des formes sur images aériennes

Inventaire des lacs thermokarstiques

Outil de signalement en ligne, version provisoire





Action 3.2 – Etude de cas de lacs thermokarstiques

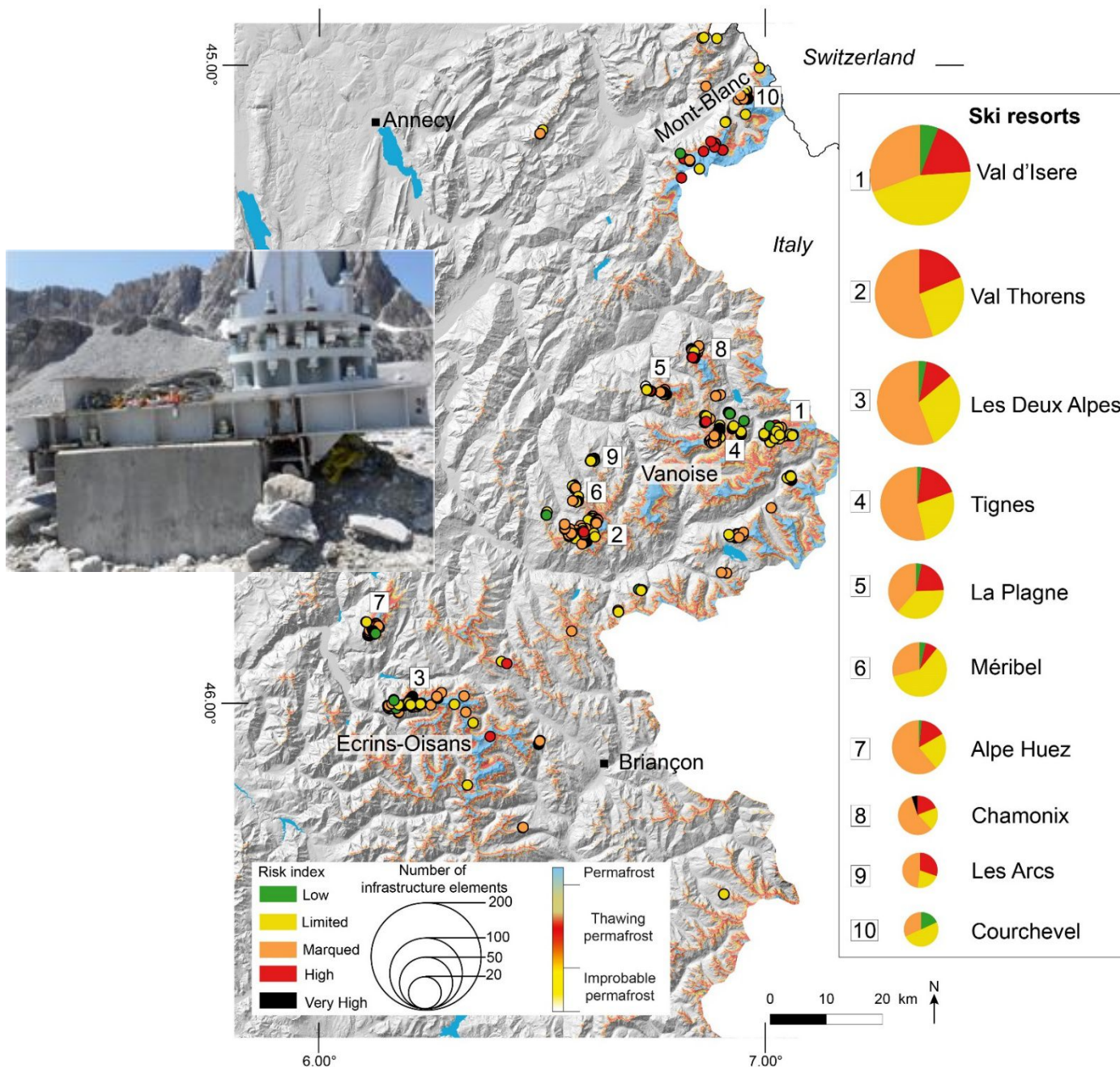
Tignes – Col des Vez

Haute-Ubaye – Lac Chauvet

étude géomorphologique
étude diachronique
géophysique
calcul des volumes

Etudes en cours

Publications en préparation



Action 2.3 – Inventaire des infrastructures sur permafrost

Inventaire des infrastructure

Elaboration d'un indice de risque

Regional Environmental Change (2019) 19:1281–1293
<https://doi.org/10.1007/s10113-019-01465-z>

ORIGINAL ARTICLE



Recent evolution of damage to infrastructure on permafrost in the French Alps

Pierre-Allain Duvillard^{1,2} · Ludovic Ravel¹ · Marco Marcer³ · Philippe Schoeneich³

Received: 12 February 2018 / Accepted: 23 January 2019 / Published online: 11 February 2019
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Abstract

The past four decades have seen extensive development of the winter sport industry in the French Alps and several hundred ropeway transport systems have been installed in areas where mountain permafrost may be present. Due to current climatic change and the ensuing permafrost degradation, the vulnerability of these infrastructures to destabilization may increase. Therefore, there is a real potential for instabilities to develop on ropeway transport systems in the Alps, requiring a better understanding of these processes. This study investigates the relation between permafrost and infrastructure stability in the French Alps, seeking to understand the evolution of this phenomenon over the past decades. This was done by following a two-step analysis. At first, the infrastructure elements built on modeled permafrost-affected areas were inventoried at the scale of the French Alps in order to get an overview of the possible vulnerabilities. Then, our study presents a detailed historical inventory of damage to infrastructure over the past three decades in different geomorphologic contexts. Overall, in the French Alps, there are almost 1000 infrastructure elements located in permafrost areas among which 12 (i.e., 24 infrastructure elements) were identified to have been subject to repeated instances of disruption and deterioration and most of the damages recorded were in areas where permafrost degradation is fully expected (ice-rich terrain). Infrastructure recovery costs may be significantly high, making this issue a relevant consideration to be included in the design process.

Keywords Mountain permafrost · Infrastructures · Damages · Climate change · French Alps

Action 3.3 – Sensibilité et vulnérabilité des infrastructures

Des analyses d'endommagement
Des historiques de dommages et de gestion
Une analyse des stratégies

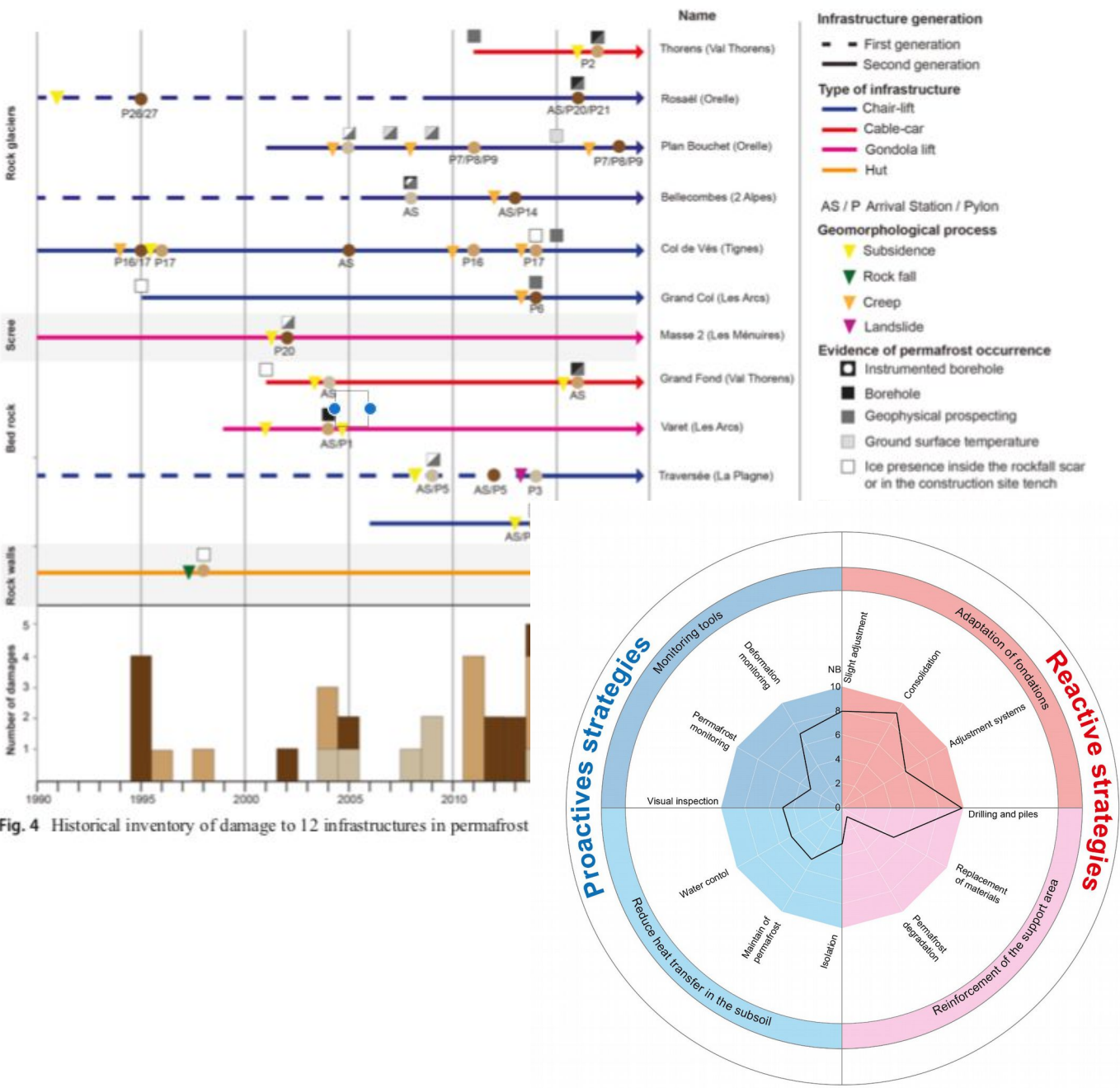


Fig. 4 Historical inventory of damage to 12 infrastructures in permafrost

Regional Environmental Change (2019) 19:1281–1293
<https://doi.org/10.1007/s10113-019-01465-z>

ORIGINAL ARTICLE



Recent evolution of damage to infrastructure on permafrost in the French Alps

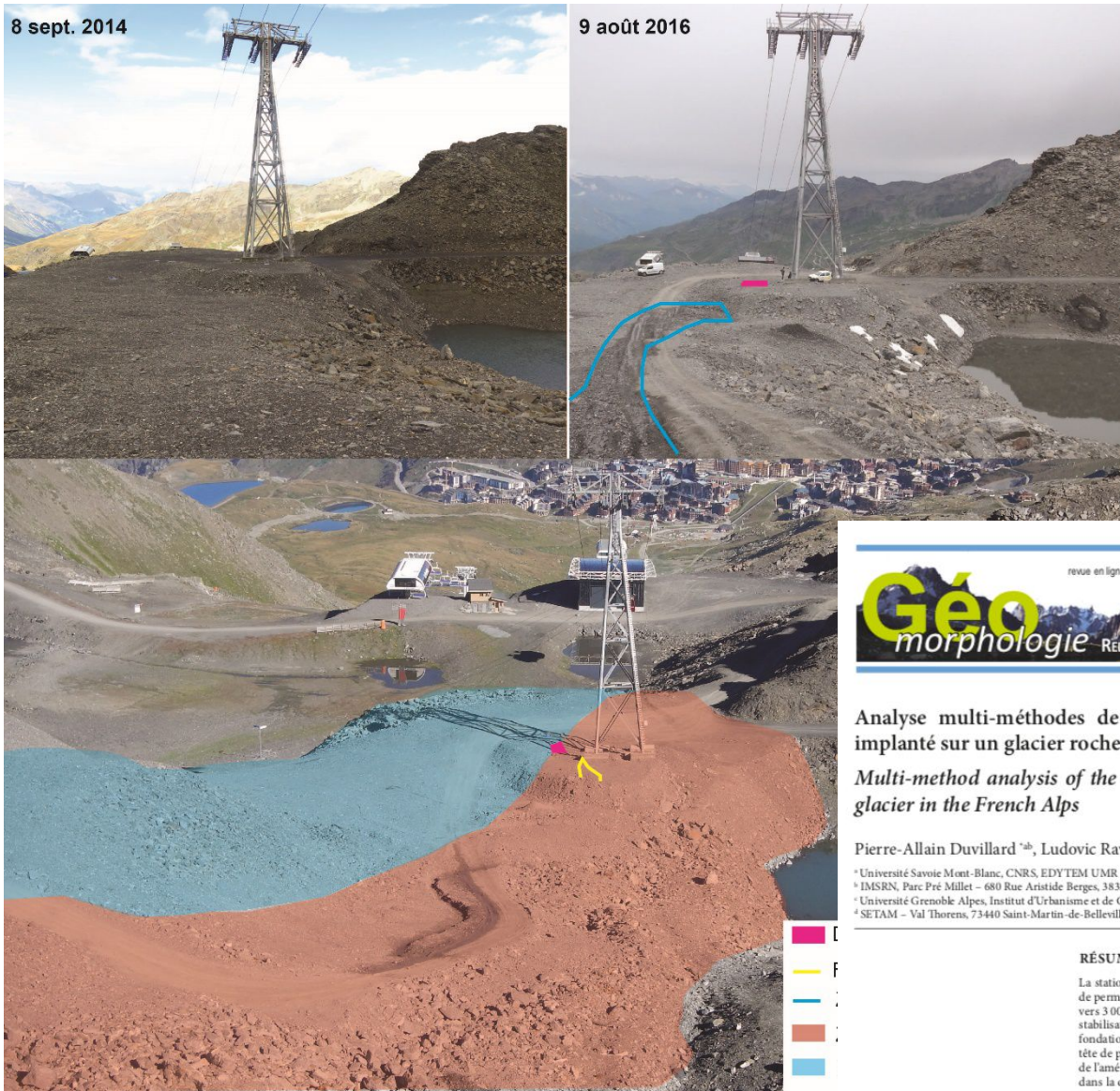
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Abstract

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Keywords Mountain permafrost · Infrastructures · Damages · Climate change · French Alps



Action 4.3 – Etudes de cas d'infrastructures

Val Thorens – Funitel de Thorens
Refuge CAF de la Pilatte
Refuge CAF des Cosmiques

frontiers
in Earth Science

ORIGINAL RESEARCH
published: 31 July 2019
doi: 10.3389/feart.2019.00094



Analyse multi-méthodes de la déstabilisation d'un pylône de remontée mécanique implanté sur un glacier rocheux des Alpes françaises

Multi-method analysis of the destabilization of a mechanical lift tower located on a rock glacier in the French Alps

Pierre-Allain Duvillard^{1,2*}, Ludovic Ravanel³, Philippe Schoenbach⁴, Marco Mazzariello¹, Jean-François Bédard⁴

¹ Université Savoie Mont-Blanc, CNRS, EDYTEM UMR 5204 – Bâtiment « Pôle 1 »

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⁴ SETAM – Val Thorens, 73440 Saint-Martin-de-Belleville, France.

RÉSUMÉ

La station de Val Thorens (Savoie) de permafrost probable. Au cours de 3 000 m d'altitude, ont subi une déstabilisation. Cet article documente les fondations ont été affectées par la tête de pylône par rapport au processus de l'aménagement d'une piste dans la déstabilisation et de cas sur la dynamique du glacier rocheux porteur fondée sur des données de terrain, obtenus par photogrammétrie. Cette étude met en évidence le danger d'un milieu riche en glace ti

Mots clés : Remontées mécaniques.

AGU100
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EARTH AND
SPACE SCIENCE

Journal of Geophysical Research: Solid Earth

RESEARCH ARTICLE
10.1029/2018JB015965

Key Points:

- Induced polarization of rock glacier is investigated. During freeze and thaw, rocks show two polarization effects.
- Surface conductivity controls the rock electrical conductivity of rocks during freeze and thaw.
- An experiment and a field study on an Alpine rock glacier are performed to investigate the electrical conduction in freezing conditions.

Correspondence to:
A. Revil

Three-Dimensional Electrical Conductivity and Induced Polarization Tomography of a Rock Glacier

P. A. Duvillard^{1,2}, A. Revil³, Y. Qi³, A. Soueïd Ahmed³, A. Coperey³, and L. Ravanel¹

¹ Université Grenoble Alpes Université Savoie Mont-Blanc, CNRS, UMR CNRS 5204, EDYTEM, Le Bourget du Lac, France, ² IMSRN, Montbonnot-Saint-Martin, France, ³ Université Grenoble Alpes, Université Savoie Mont-Blanc, CNRS, IRD, IFSTTAR, ISTerre, Grenoble, France

Abstract Three-dimensional electrical resistivity and induced polarization data were collected on an unstable Alpine rock glacier in Val Thorens (Vanoise massif, France). In addition to these field data, we also performed induced polarization measurements during freeze and thaw using a soil sample and the poorly mineralized water, both from this site. In the tomograms, the electrical conductivity and the normalized chargeability show very distinctly the presence of the rock ice mixture. The chargeability itself is however quite constant over the entire investigated area with the exception of a small area associated with the presence of carbonaceous rocks rich in graphite. The background chargeability is close to the dimensionless

Paraglacial Rock Slope Adjustment Beneath a High Mountain Infrastructure—The Pilatte Hut Case Study (Écrins Mountain Range, France)

Pierre-Allain Duvillard^{1,2*}, Ludovic Ravanel^{1,2}, Philip Deline¹ and Laurent Dubois⁴

¹ IMSRN, Parc Pré-Millet, Montbonnot, France, ² CEREMA, Direction



outcome of global climate change. Infrastructure in mountain areas has affected the Pilatte Hut in the 1980s. We reconstructed the Scanning and quantified the annual crack surveys have revealed movements initiated in the 1980s seem to be toward a significant past images taken since 1980 that the glacier probably advanced during the 1980s, until the present day. The surface change suggests glacier surface changes, and glacier change.

er Scanning, crack-meters, high

Bilan

Un jeu de données homogènes couvrant l'entier du territoire alpin français

Un jeu de données unique à ce jour dans les Alpes

De nombreuses études de cas

Des sites de suivi de l'évolution des phénomènes

2 thèses soutenues, 1 en cours
11 articles scientifiques publiés,
1 soumis, 2 en préparation

... une rétention des données

Diffusion des données sur demande à certains partenaires seulement

Suspension de la publicité

... des partenaires opérationnels ...

RTM partenaire du projet + DGPR - PAPROG

Deux communes : Val Cenis - Lanslevillard + Les Houches

Parcs : PNE, PNV, PNR-Q

Stations de ski : « circulez, rien à voir »

Absence d'interlocuteurs dans régions et départements

... des partenaires financiers déficients ...

FEDER – des retards considérables et un refus de dépenses massif
35 % versés après 4 ans de projet ...

FNADT – un déficit structurel de 13'000 €
... sauvé (peut-être) par le COVID ...