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CHARACTERISING THE DISTRIBUTION AND EVOLUTION OF PERMAFROST IN INTERMEDIATELY STEEP MOUNTAIN SLOPES

BEN ROBSON¹
CHRISTOPHE LAMBIEL¹
FLORENCE MAGNIN²

¹ Institute of Earth Surface Dynamics, University of Lausanne, Switzerland
² Environnements, Dynamiques et Territoires de la Montagne (EDYTEM),
Université de Savoie-Mont-Blanc, France

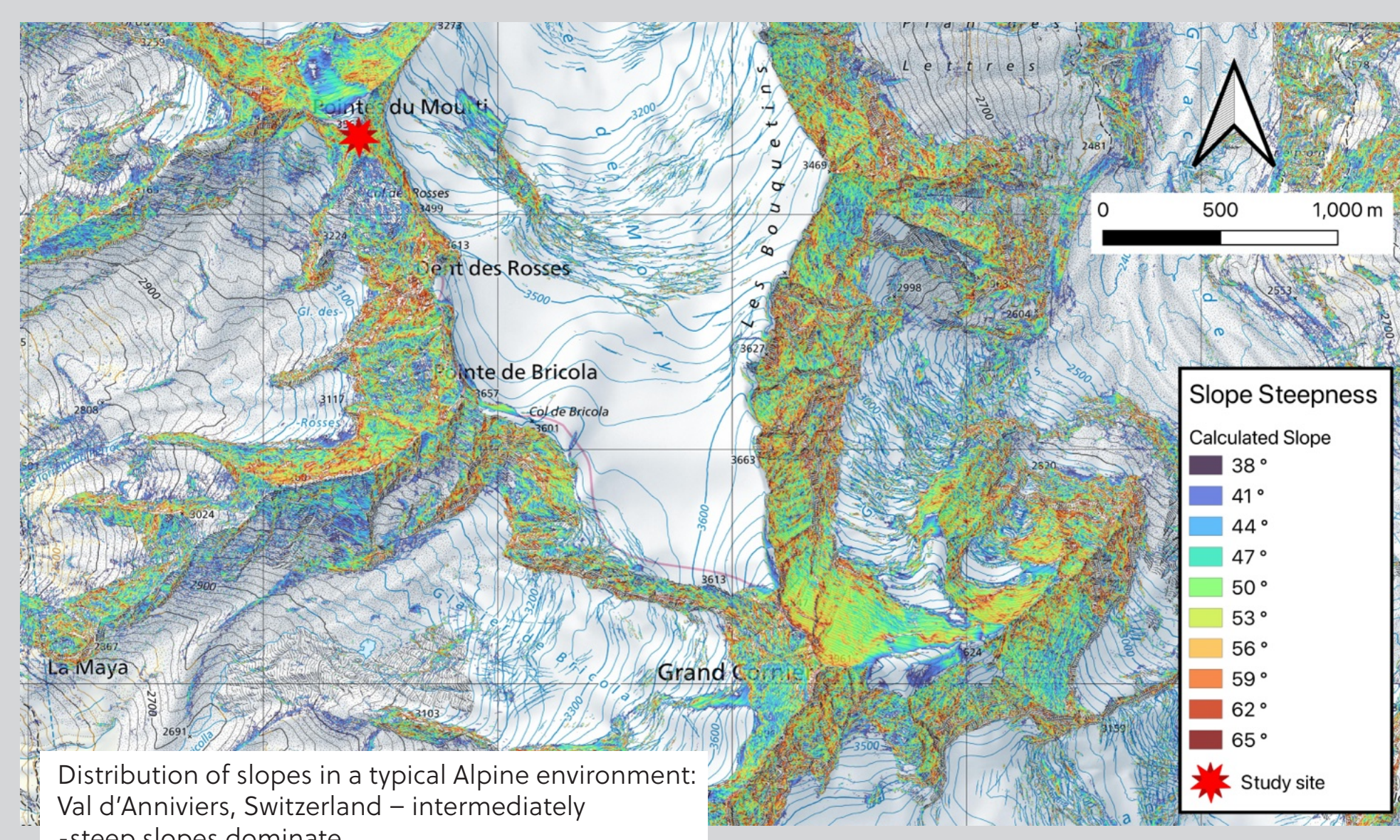
CORRESPONDING AUTHOR
ben.robson@unil.ch



INTRODUCTION

The distribution of permafrost is relatively well understood in steep rock faces and debris-covered areas, yet our knowledge remains limited for the intermediately-steep mountain slopes (38° - 70°). Complex microtopography in these slopes leads to strong variations in solar radiation, snow cover extent and snow depth across short distances, along with variations in grain size of surface debris and extent of bedrock fracturing. This results in highly variable local thermal conditions that influence permafrost presence.

Intermediately-steep slopes cover a significant proportion of the Alpine environment above 2000 m a.s.l. where permafrost can be present: in Switzerland alone they cover 2760 km², 7% of the total area of the territory.



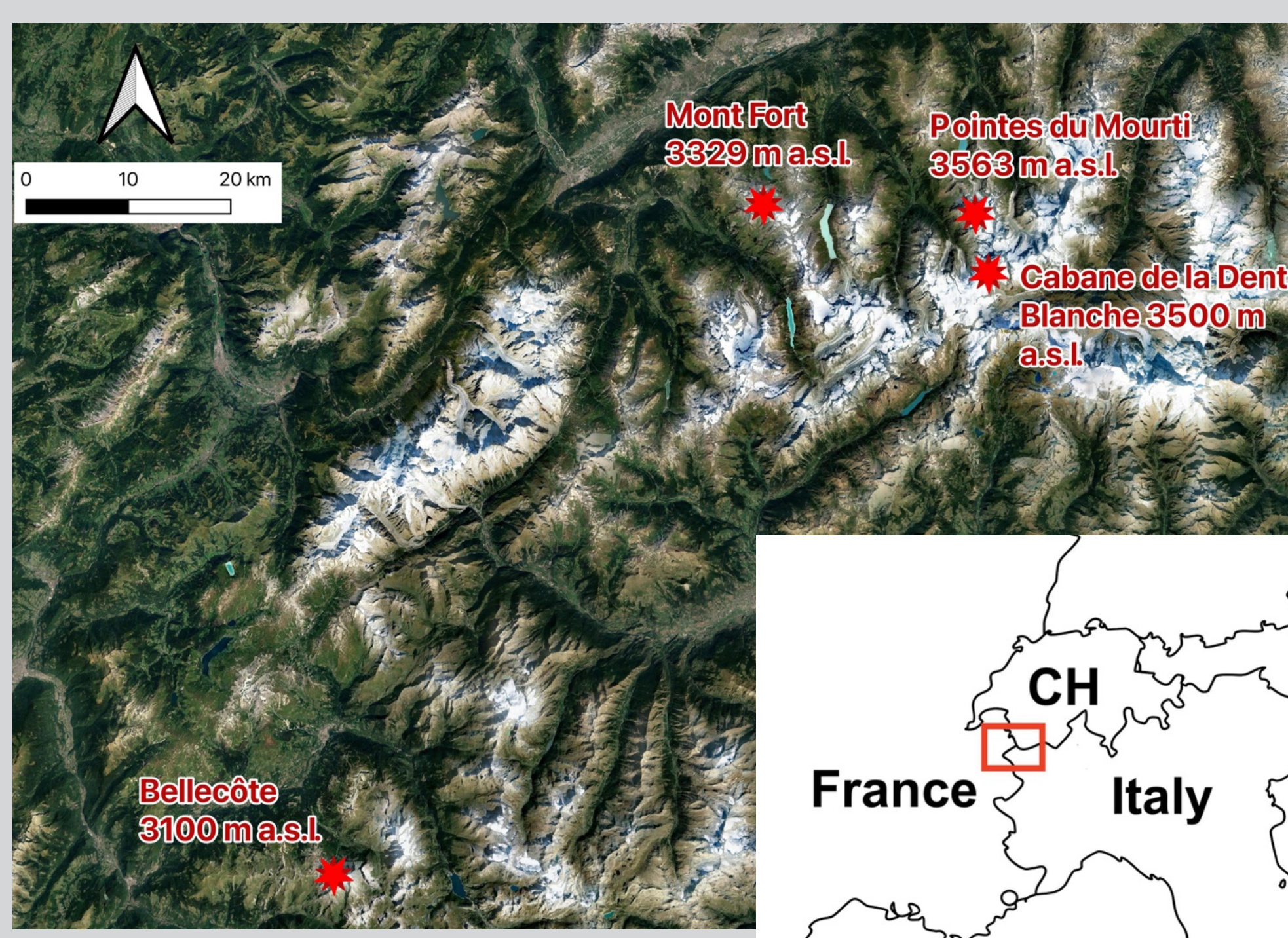
Permafrost models rely on calibration from in-situ measurements, so extreme variability in ground temperatures poses problems. Given the lack of available data, statistical approaches struggle to capture these characteristics (Boeckli et al., 2012), thus regional maps are an approximation of the actual conditions. There is a clear need to better investigate permafrost distribution in these slopes.

OBJECTIVES

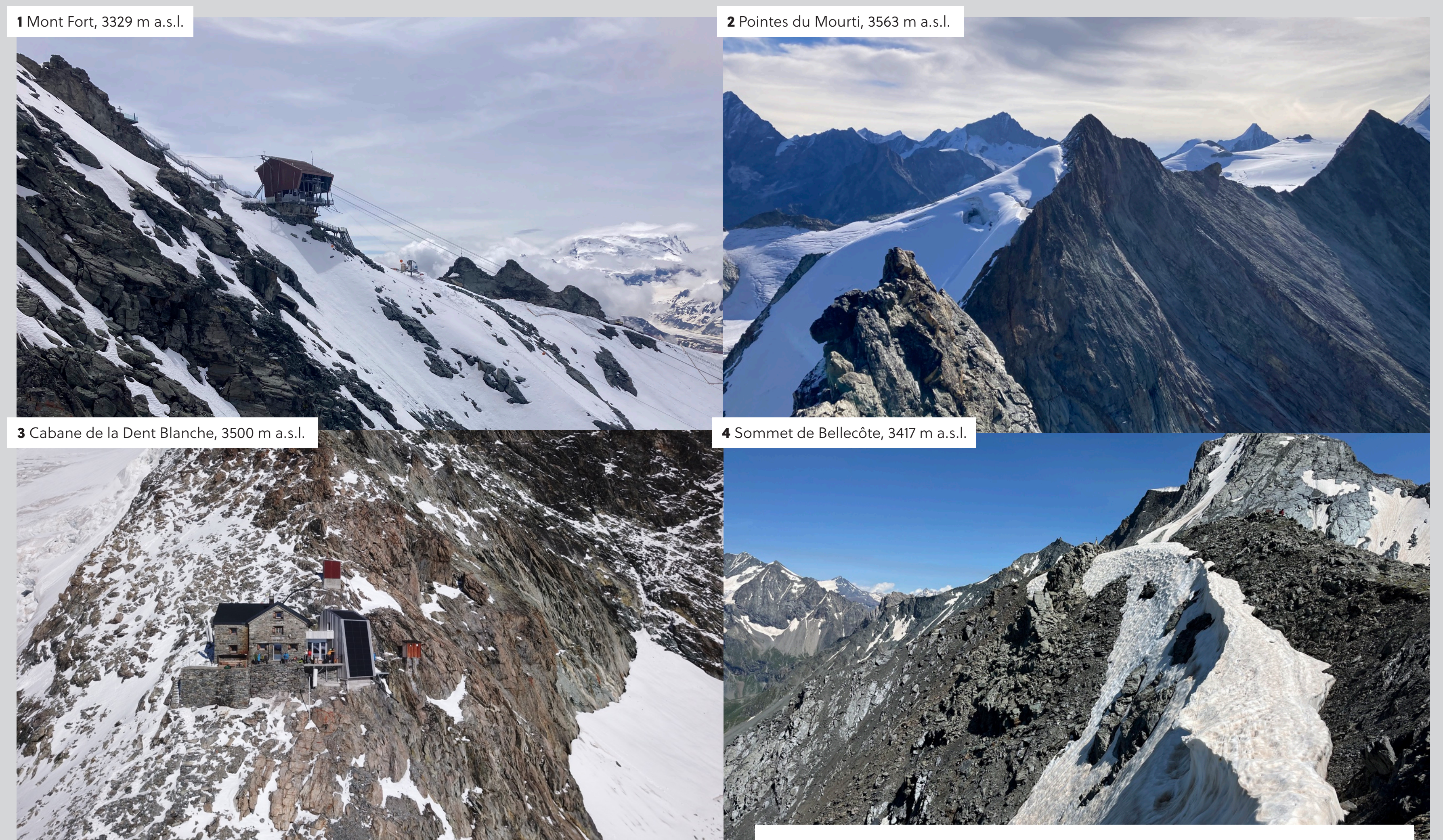
The five-year PhD project aims to address these research needs by:

1. Characterising the distribution and evolution of permafrost in intermediately-steep slopes of selected study sites.
2. Developing an improved permafrost distribution map on a regional scale within the European Alps.

STUDY AREAS



Selected study sites: Mont Fort (3329 m a.s.l.), Pointes du Mourti (3563 m a.s.l.), Cabane de la Dent Blanche (3500 m a.s.l.) in the Swiss Pennine Alps, and Sommet de Bellecôte (3417 m a.s.l.) in Savoie, France. These sites span a range of altitudes within the permafrost zone, encompass diverse lithologies, and vary in topographical configurations.



Terrain challenges
Loose, steep, debris-covered slopes of highly fractured bedrock – a “house of cards”.

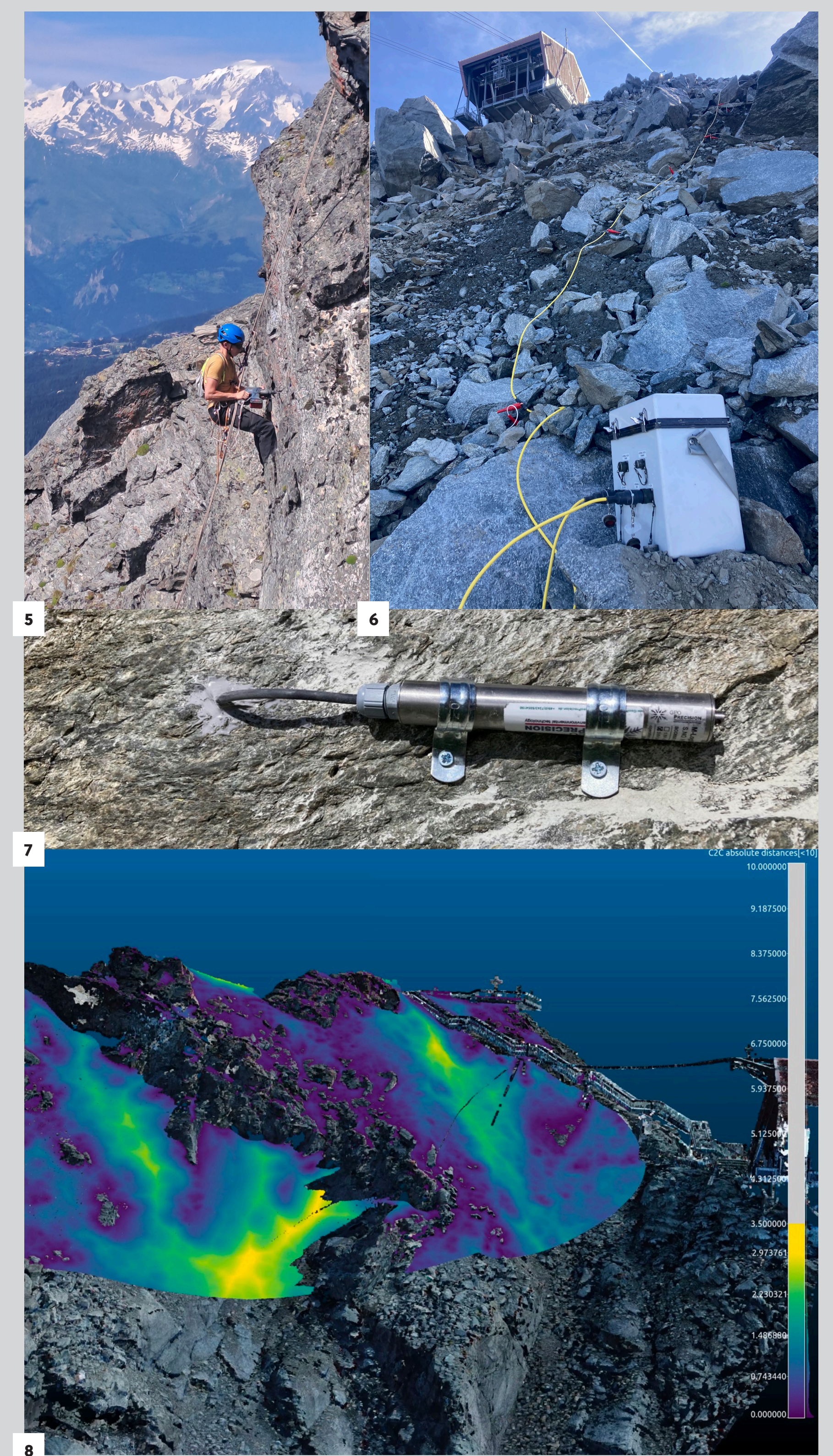
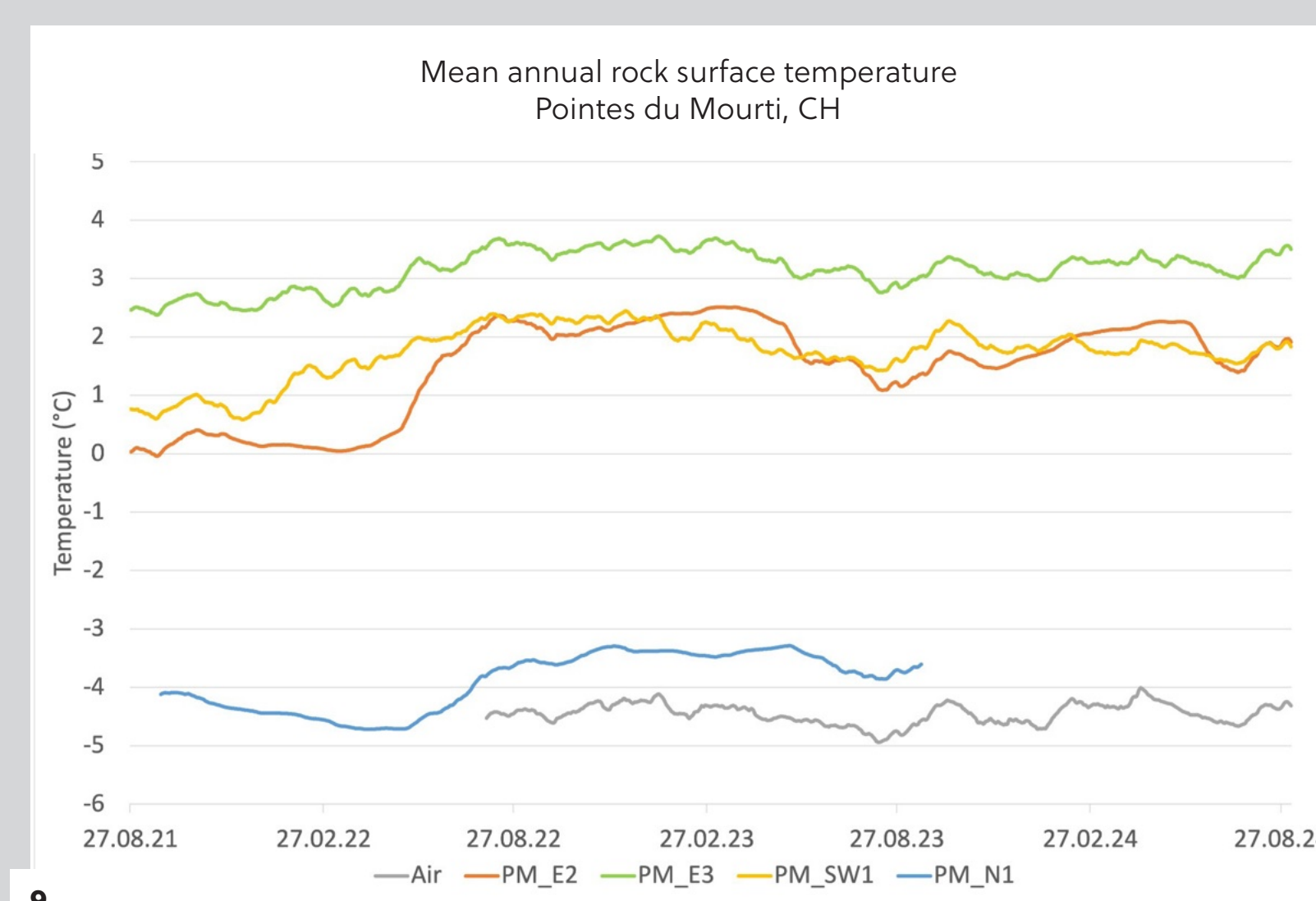
Solutions
Mountaineering techniques to facilitate access. Installation of sensors during winter with a protective snow cover. Radio link temperature sensors to ease the harvesting of data and limit exposure to slope hazards.⁷

METHODS

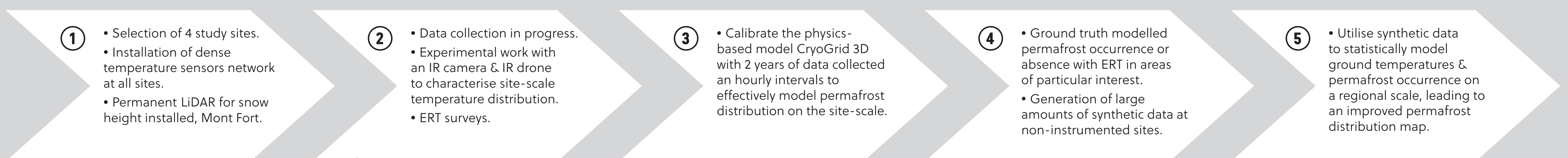
Our data acquisition strategies include:

- Recording of near-surface rock and debris temperatures^{5,7}
- Borehole ground temperature measurements
- Ground truthing with electrical resistivity tomography (ERT) surveys⁶
- Slope monitoring by drone-based Structure-from-Motion photogrammetry
- Snow depth quantification by drone & LiDAR³
- Englacial temperature monitoring
- Infra-red imagery for characterising temperature distribution

Near-surface rock temperatures can vary drastically over short distances⁴. The complex factors governing mountain permafrost necessitate a high-resolution, spatially distributed, physics-based approach for accurate modelling (Haberkmorn et al., 2017). Consequently, our measurement networks at each site are densely configured. Once a substantial dataset is collected, we will calibrate the physics-based model CryoGrid 3D (Westermann et al., 2016) where the Mean Annual Air Temperature (MAAT), incoming solar radiation, surface rugosity, evolution of snow depths, and terrain configuration are studied in detail. The calibrated model can then be used to produce synthetic data at points in non-instrumented sites. Once enough synthetic data is generated, they can subsequently be utilised in robust statistical models, leading to improved permafrost mapping on the regional scale.



PROJECT PROGRESS



YOU ARE HERE

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