CASE STUDY

Going Against the Pack: An Innovative Way to Forecast Avalanches in the Alps

For many people, picturesque alpine ski resorts such as those in Valle d'Aosta, Italy, evoke feelings of serenity and peace. But they may not be as idyllic as they appear.

Avalanches, a persistent risk for snow-capped regions, threaten the safety of people who inhabit or visit the area. Mountains cover 25 percent of the world's land surface and latest estimates indicate that 12 percent of the world's population live in mountainous areas. The European Alps are the most densely populated mountainous area in the world, with about 13 million people. Those numbers increase exponentially in the winter with the arrival of tourists [1].

Being able to accurately forecast these natural phenomena can be a matter of life and death. At a minimum, accurate forecasts can help avoid large potential liabilities for loss of business or infrastructure. An effective prevention strategy could have averted or mitigated several accidents around the world in recent years. Cost-effective strategies for risk mitigation invariably require avalanche forecasting tools. Such tools use knowledge of several physical parameters of the snowpack, such as thickness and average snow density.

Company:

- University of Pavia

Key Issues:

- Make timely and accurate snow avalanche forecasts
- Monitor the snowpack evolution in a continuous fashion

Solutions:

- Testing the snow condition in a safe way using a cost-effective radar technology

Results:

- Lower-cost solution
- Inherently safe and accurate
- Nondestructive

The Challenge:
Make Accurate Snowpack Measurements When Needed, Not Only When Possible

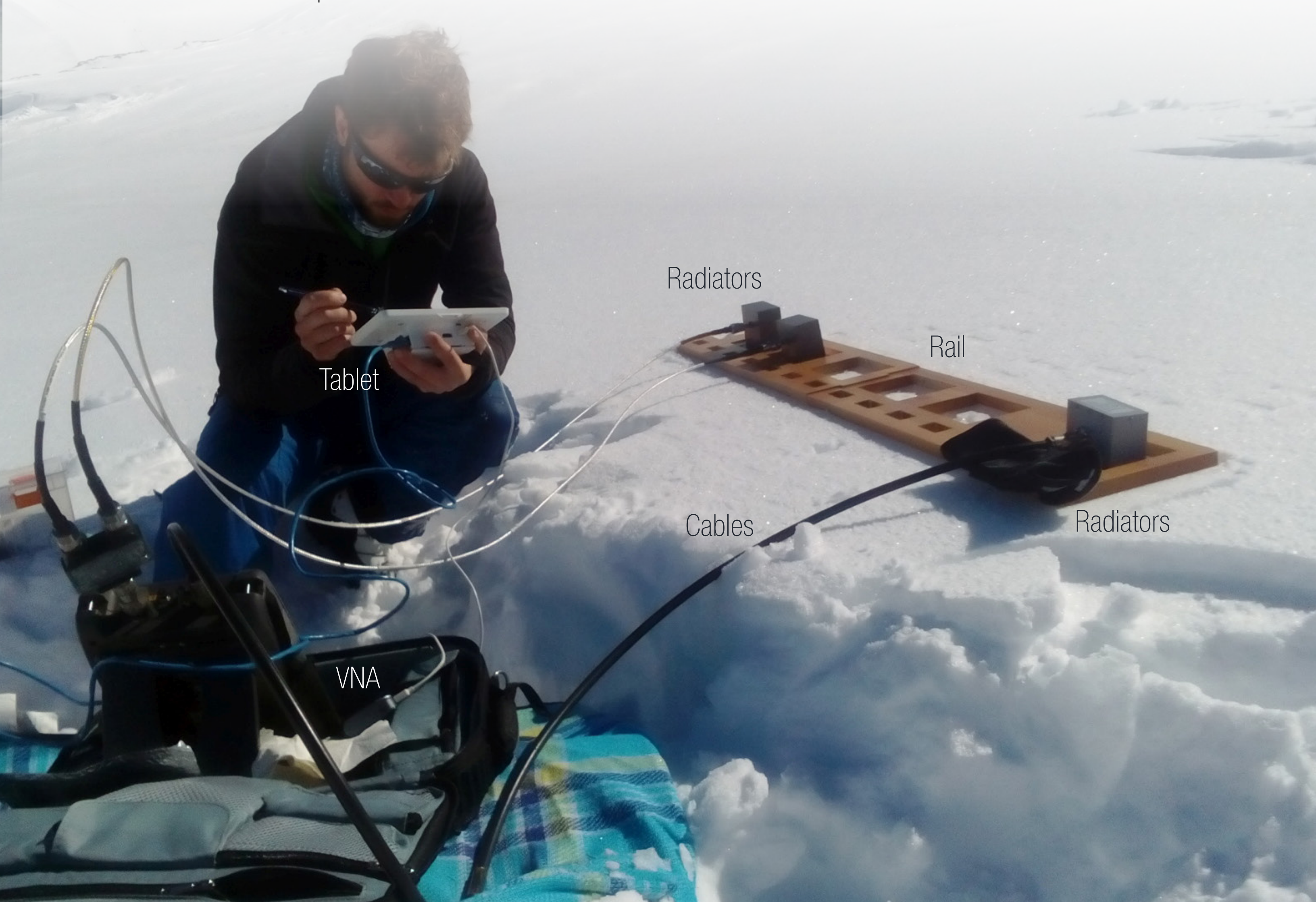
The most common method for measuring snowpack parameters relies on manual analysis of snowpack through in situ excavation of snow pits – a very time-consuming, but very accurate approach. For safety reasons, surveyors cannot apply this method when and where it is most needed — along critical slopes and under bad weather conditions. Excavations of this type are feasible at only a few select sites. Extension of measurement results to other parts of the snow slope depends on the uniformity of the slope's topography. Moreover, excavations are destructive and do not easily allow for continuous monitoring of changes in the snowpack.

The University of Pavia took a different approach to overcome these constraints. Its innovative method uses microwave radars to deliver a rapid, nondestructive, and automatic analysis of the snow structure.

The Solution:
Testing the Snow in a Nondestructive and Safe Way

The University of Pavia's SNOWAVE system consists of a dual-receiver radar with one transmitter and two receivers, each connected to its own radiator. SNOWAVE simultaneously measures propagation distance, wave speed, and attenuation of the snowpack from its surface. As a result, the system can estimate snow depth, density, and liquid water content at the same time without the use of any other equipment.

The university selected Keysight's FieldFox portable network analyzer as its primary measurement tool. Its innovative and durable design, which includes no fans or vents and a sealed enclosure, makes FieldFox an ideal fit for this application, as it can withstand a hostile environment. The system will take advantage of the instrument integrated LAN capability to control the measurement and data transfer. Each transmitter–receiver pair works as a standard frequency-modulated continuous-wave (FMCW) radar, determining the time of flight between the measurement plane and the target. The dual-receiver architecture allows the system to resolve the ambiguity of the unknown medium, such as snow thickness and snow wave speed. From the data, sophisticated software extrapolates information, such as dielectric permittivity, that can be correlated to the parameters described above.



The Result:
Continuous, Accurate, and Low-Cost Snowpack Monitoring

The university successfully demonstrated the feasibility of this system at altitudes up to 3,000 meters at Valle D'Aosta and in the Arctic. Traditional in situ excavation techniques benchmarked the effectiveness of the new radar solutions. Figure 1, below, shows the radar trace acquired in two time slots. Red lines represent the location of interfaces as determined by the manual snowpack analysis. This new methodology detects not only the reflection at the snow–ground interface, but also the internal interfaces, based on the stratigraphy of the snowpack and how it changes over time. The nondestructive, radar-based solution monitors the snowpack continuously in any weather condition to substantially improve avalanche forecasting tools at lower cost.

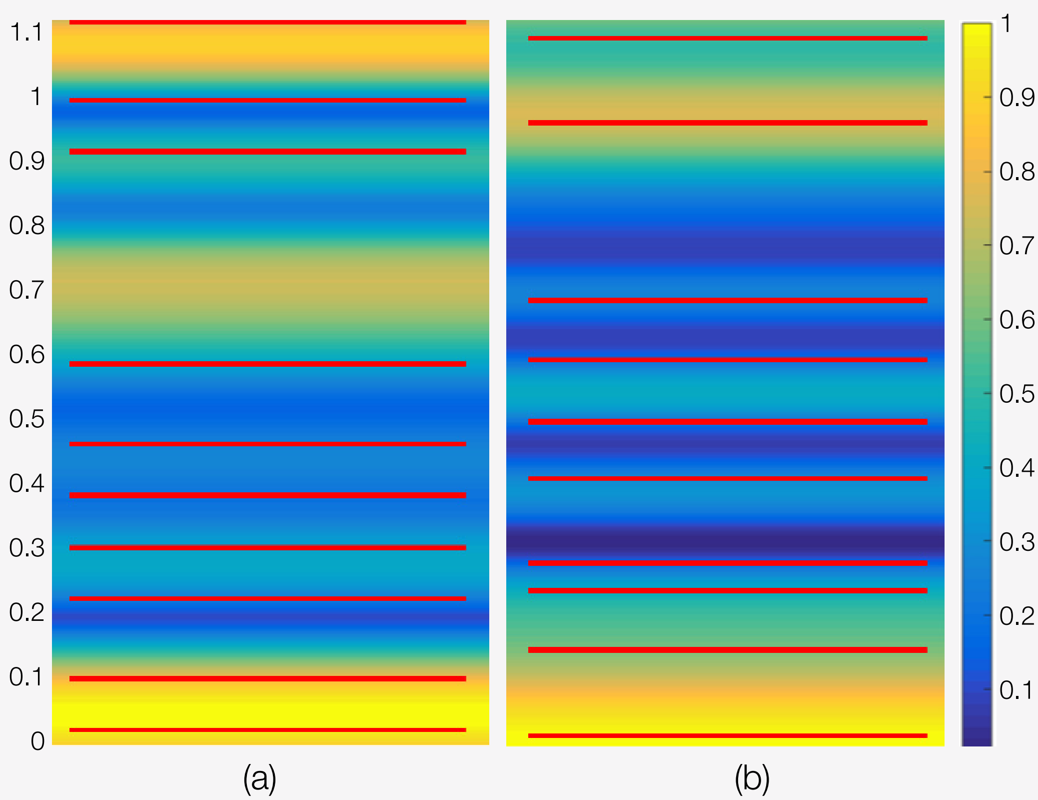


Figure 1. Radar traces (normalized magnitude of the reflected signal) for in outdoor validation: (a) February 2017, (b) March 2017. Red lines represent the location of interfaces as determined by the manual snowpack analysis.

Related Information

[1] K. Lied, "SATSIE Avalanche Studies and Model Validation in Europe – Final Report," European Commission Fifth Framework Programme, May 31, 2006.

P. F. Espín-López, M. Barbolini, E. Ceaglio, F. Dell'Acqua, P. Dellavedova, L. Silvestri, and M. Pasian, "SNOWAVE, A Novel FMCW Radar Architecture for Snow Cover Monitoring," International Snow Science Workshop 2018, Innsbruck, Austria, October 7–12, 2018.

M. Pasian, M. Barbolini, F. Dell'Acqua, P. F. Espín-López, and L. Silvestri, "Snowpack Monitoring Using a Dual-Receiver Radar Architecture," IEEE Transactions on Geoscience and Remote Sensing, Vol. 57, No. 2, pp. 1195–1204, February 2019.

Learn more about Keysight's FieldFox HandHeld Analyzers:

- FieldFox Brochure
- FieldFox Product Details