


# Case Study

## Geoscience

## Company Overview

Z+F is one of the world's leading manufacturers in the field of non-contact, terrestrial laser measurement technology. From years of research, development and numerous successful engineering projects, Z+F is the forerunner in this field with a wealth of knowledge, experience and success.

When it comes to implementing future developments Z+F has always encouraged innovative thinking and open-minds. Our loyal and long-standing customers appreciate our continual innovations, support and services we provide.

# Introduction

Geoscientists, such as Geologists, Glaciologists or Geographers, aim to numerically monitor changes of the earth's surface over time in order to accurately describe certain geomorphological phenomena. This scientific domain is referred to as Geomorphometry where changes in area, volume or motion of particular landforms are measured.

Terrestrial laser scanning (TLS) has proved its potential in Geoscience and has established its place in this field of science and technology. The applicability of a certain laser scanner for a specific problem depends on a mixture of characteristics such as the maximum range, the precision of the rangefinder as well as the lateral resolution. In geoscience, the observation of glaciers is clearly dominated by long-range scanners that deploy the time-of-flight principle while several other tasks, for example rockfall monitoring and outcrop modelling can be approached by using the latest generation phase-based terrestrial laser scanners measuring ranges of several hundred metres.

A distinct advantage of the Z+F IMAGER® 5016 over long-range systems is its superior precision of the rangefinder, as well as a potentially higher lateral resolution due to a smaller laser diameter. In this case study, several fields of application for deformation monitoring in alpine environments using phase-based-TLS are briefly demonstrated. All examples in this case study were captured using the Z+F IMAGER® 5016 at the Innsbruck Summer School of Alpine Research, which took place in and around Obergurgl in the Austrian Alps in 2017.

## Innsbruck Summer School of Alpine Research

International junior scientists in the fields of mountain research, geoinformatics and remote sensing take part in the Innsbruck Summer School in Obergurgl, Austria, which is held every two years. The main goal is to provide participants with innovative, practical and methodological skills to characterize complex terrain and object features.
By employing the Z+F IMAGER® 5016, the young scientists are able to use a high-precision TLS for generating the data, which delivers highly accurate measurement results at long distances.

isprs ÖAW IGF
universität innsbruck

*Captured spot that is subject to rockfall. Z+F IMAGER® 5016 in Obergurgl, Austrian Alps*
*Picture: Dr.-Ing. Daniel Wujanz*

# Rockfall Monitoring

Z+F IMAGER® 5016
*Picture: Dr.-Ing. Daniel Wujanz*

The occurrence of rockfall is a common sight for every visitor in an alpine region. It would been seen during a challenging hike towards a summit, or alongside a road that is located besides a steep rock face. This effect is triggered by various causes - cycles of freezing and thawing, pressure in cracks that are provoked by water or vegetation root pressure are common causes.

The monitoring of rockfall by means of terrestrial laser scanning has been a continuously field of research in the past several years. A vital task before the actual deformation monitoring process can be initiated, is to remove vegetation from the original datasets so that the growth of plants is not mistaken with actual surface changes.

A second aspect why the localisation of vegetation is of particular interest is the fact that erosion may be caused by root pressure. It would normally be quite tedious to manually select all plants from the scanned region of interest, since vegetation is scattered across the rock face. However, several approaches have been developed in order to automate this task, for instance purely based on geometric characteristics.

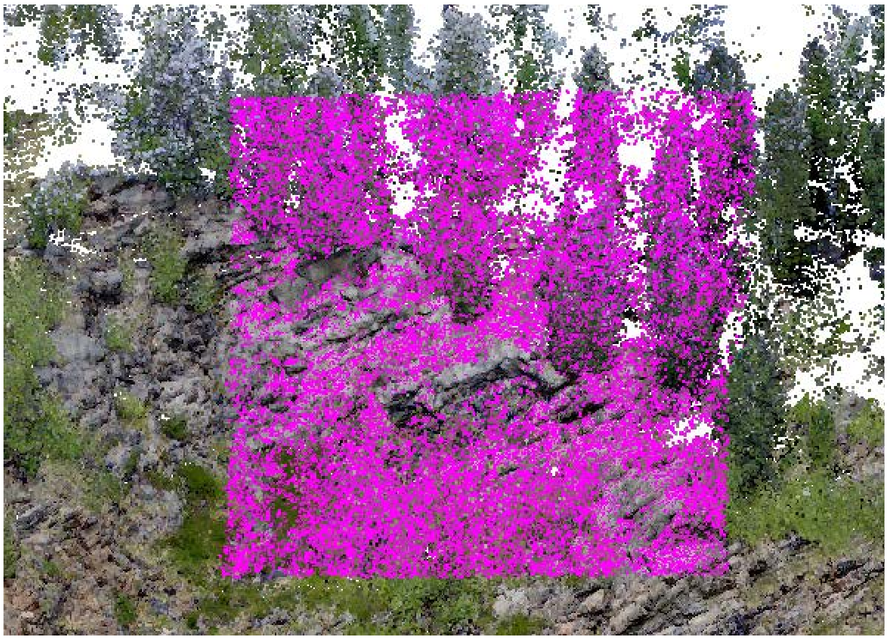
An alternative approach based on radiometric information is the combination of TLS data with images captured by a modified digital camera whose near infrared (NIR) filter has been removed while an RGB filter was added. By this, the camera exclusively captures information reflected in the NIR-spectrum which helps to identify vegetation.

While the previous approach requires an additional modified sensor and laborious calibration of the sensor system, an alternative strategy is proposed in the following. The general idea is to compute a normalised difference vegetation index (NDVI), purely based on information that is captured by the Z+F IMAGER® 5016.

Information within the visible spectrum is acquired by its built-in camera that is already calibrated in relation to the TLS by the manufacturer. The last required piece of information from the NIR-spectrum is retrieved from the rangefinder in form of intensity values. Since both sources of information feature quite different numeric ranges an adaption process is necessary before the actual NDVI can be computed.

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

The visible spectrum information (RED) band is acquired by a fully calibrated built-in camera by Zoller + Fröhlich, whereas the last required piece of information about the NIR spectrum is retrieved from the rangefinder in form of intensity values. Since required parameters for example RED and NIR bands are available for each pixel, the NDVI values can be calculated by using the above stated formula.



*A rectangular region highlighted in pink ink to show the points classified as vegetation*

*Captured spot that is subject to rockfall. Z+F IMAGER® 5016 in Obergurgl, Austrian Alps*
*Picture: Dr.-Ing. Daniel Wujanz*

# Entity-based deformation monitoring

Another application area in geoscience is deformation monitoring, for example glacial deformation, landslides and rockfalls.

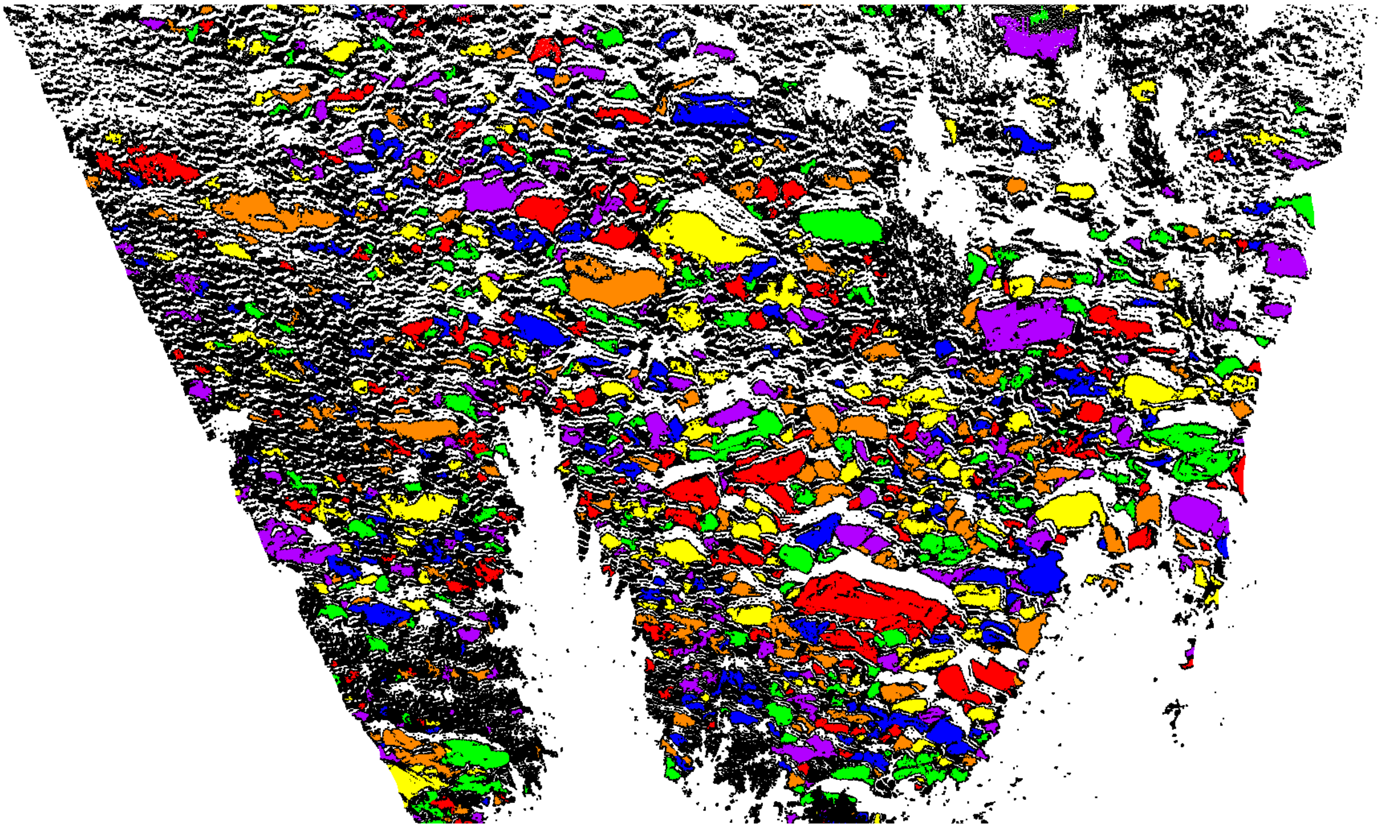
While established methods for deformation monitoring based on point clouds allow to draw conclusions at an aerial level, geoscientists are much more interested to analyse individual behaviour of single entities such as rocks or boulders. Parameters that are of particular interest in this context are for instance the orientation of rock faces, fault planes or displacement vectors.

In order to derive point-wise displacement vectors, image correlation algorithms are deployed on intensity images. A disadvantage of this strategy is the dependency of the results to ambient influences such as rainfall that notably influences the recorded intensity values and hence the outcome. An object-based monitoring approach based on terrestrial laser scans is tailored to be applied in landslide monitoring and contains a sophisticated rule-based segmentation algorithm.

Due to its accessibility, Obergurgl in the Austrian Alps serves as a study area for this novel entity-based deformation monitoring algorithm. A challenging step for any algorithm of this kind is the segmentation of the point cloud into individual geological entities and yet again, to identify vegetation in the acquired data.

While this approach mentioned before is based on radiometric information there are also other methods which generate their results by using geometric information. In order to use both sources of information for monitoring a segmentation algorithm has been applied. Apart from using geometric and radiometric information the algorithm also considers local sampling characteristics that would otherwise bias the outcome.

It is shown in the following segmented point cloud that the rock grain size, another characteristic of great interest for geologist, varies notably within the captured area. In order to match individual entities over time, meaningful and stable descriptors have to be developed in the future.



*Segmented point cloud*

*Debris field captured by the HDR camera of the Z+F IMAGER® 5016, Obergurgl, Austrian Alps*
*Picture: Dr.-Ing. Daniel Wujanz*

# Conclusion


Z+F IMAGER® 5016

Phase shift terrestrial laser scanner

Range: 360 m
Weight: < 6,5 kg
View: 360° x 320°
Measurement rate: > 1 Mio. points/sec
Protection class: IP 54
Integrated HDR camera
and positioning system

These first experiences with the phase-based Z+F IMAGER® 5016 in geo-scientific applications – a challenging domain that is clearly dominated by time-of-flight scanners - reveal the potential of phase based laser scanner in this ambit. Due to its notably increased range in comparison to previous models new fields of application can be conquered such as rockfall monitoring or entity-based deformation monitoring.

A clear advantage of the Z+F IMAGER® 5016 for the use in rockfall monitoring in comparison to camera-view scanners is its larger field of view, allowing to capture very steep rock faces at comparably close ranges at superior precision to long range scanners.

Apart from the two featured fields of application the scanner could also be used in monitoring mass movements of large landslides. Due to its very fast acquisition rate numerous scans can be captured along the landslide which allows very short stays at each scan position in a hazardous environment.

And still the potential of this TLS has not been exhausted by a long way yet. There are numerous opportunities where the terrestrial laser scanner Z+F IMAGER® 5016 can be used. Applications up to the range of 360 m are ideal use cases, such as cave scanning with built-in indoor navigation system, geological outcrop modelling, volume estimation, drill core scanning, bedrock channel analysis, erosion studies or rocks and minerals classification. People have successfully employed laser scanners in these domains and bring their scientific understanding to the next level.

**Head office – Germany**
**Zoller + Fröhlich GmbH**
Simoniusstrasse 22
88239 Wangen im Allgäu
Germany

Phone: +49 7522 9308-0
Fax: +49 7522 9308-252

www.zofre.de
info@zofre.de

**Subsidiary – UK**

**ZF UK Laser Limited**
9 Avocado Court
Commerce Way
Trafford Park
Manchester M17 1HW
Great Britain

Phone: +44 161 8717 050
Fax: +44 161 3125 063

www.zf-uk.com
info@zf-uk.com

**Subsidiary – USA**

**Z+F USA, Inc.**
700 Old Pond Road
Suite 606
Bridgeville, PA 15017
USA

Phone: +1 412 257 8575
Fax: +1 412 257 8576

www.zf-usa.com
info@zf-usa.com