LAYER BOUNDARIES IN SNOW

Reflections in infrared. Snowpacks have layers. Determining their boundaries is useful – not just for avalanche warning services and winter sports. Researchers at SLF have developed a device to detect them objectively. DIAGONAL joined them for a test.

Slowly, ever so slowly, the sledge begins to tilt to one side. Lars Mewes jumps forward quickly to right it, while Benjamin Walter continues to pull the sledge behind him. Together, the physicists from the WSL Institute for Snow and Avalanche Research SLF in Davos struggle with their load through the deep snow below the Pischa ridge, lugging around forty kilograms of technical equipment.

Their most important piece of luggage is a black box – the SnowImager – which Martin Schneebeli and Benjamin developed. The researchers use it to detect layer boundaries in the snow. This is the name given to the boundary between two layers in the structure of the snowpack. They are formed either by new snow falling on top of old snow or by frost on the surface of a layer of snow freezing to form its own layer. Individual layers differ. They may, for example, have different densities and/or types of snow crystal. Knowing their boundaries and properties helps experts like the avalanche warning team identify weak layers. These layers may break either spontaneously or because pressure is applied to them, for example by a skier. There is therefore a risk that the snow lying on top of the weak layer will thunder down the slope as a slab avalanche. Avalanche forecasters usually still measure the snowpack by hand,

First, they have to shovel: Benjamin Walter and Lars Mewes dig a hole in the snow. On the right is the sledge, fully loaded with different measuring instruments.

Photos: Bruno Augsburger, Zurich

Taking measurements using infrared: the prototype of the SnowImager in action.

which is time-consuming. The SnowImager should help to speed up this process considerably. "And the resulting resolution is up to ten times as high," Benjamin says – and also more objective.

Before they can take measurements, however, they have to shovel. Lars and Benjamin dig rhythmically in unison. The snow crystals on the slope reflect the glistening sunlight. The researchers hit the bottom after digging down hundred and thirty centimetres. They widen the hole and – as a last touch – Benjamin smooths one side of the pit using a saw, trowel and brush. "The surface must be flat before we can start measuring," explains Lars.

From research to application

At last they are ready. The scientists take the SnowImager off the sledge. Then everything happens very quickly. Starting at the bottom, Lars holds the box against the snow wall several times until he gets to the top. All in all, it takes barely more than two minutes. Light-emitting diodes project infrared light, invisible to the human eye, onto the snow wall. Two small cameras in the SnowImager measure how much of the light the snow crystals reflect. The smaller the crystals are, the more light comes back. The SnowImager then takes a second pass – this time, an aperture with a slit covers its front. "This allows us to determine not only the size of the snow crystals, but also the density of the individual layers," Benjamin explains. The lower the density, the further the light penetrates into the snow layer. And the deeper it penetrates, the more it spreads laterally as the crystals reflect it. But the cameras only measure the portion of the light that comes back through the slit. Combining both values yields an analysis of the structure of the snow cover.

more pictures:

Developing the SnowImager has been a long haul – which just shows how important basic research is. Martin Schneebeli first heard about infrared films during the 1970s, when he was a teenager with a passion for photography. But

it wasn't until 1995 that he had an opportunity to try them out. By then he was already doing research at SLF. Equipped with a camera and infrared film, he set off with a colleague for the Flüela Pass. "The idea was to represent a snow profile in colour in order to distinguish the different shades of grey," Martin recalls. The attempt was successful, and the layers were clearly visible. The first doctorate on the subject was completed between 2005 and 2007. Later a device was developed to determine the size of the snow grains, but measuring the density continued to require tedious manual work. "It was only during the Corona period that we had a brainwave and realised: 'Eureka! The solution is to have a slit in front of the snow profile!'", says the former head of the 'Snow and Atmosphere' Research Unit at SLF. The idea for the SnowImager was born, and Benjamin set to work.

Ready for series production

On the first of February – a sunny day – Mirjam Eberli and Simon Grüter, from SLF's avalanche warning service, go to an off-piste slope in the Parsenn ski resort near Davos. There they also first have to dig. But when the hole is finished, things don't move as quickly as they did for Lars and Benjamin. They need to use a ram probe to see first how firmly the snowpack is compacted. Simon then runs his index finger carefully over the snow wall they have dug out to feel the transitions from one layer to the next, and calls out their height to Mirjam. Next, they use a magnifying glass and grid to analyse, layer by layer, the snow crystals' size and type. Finally, they painstakingly determine the density of the entire snow cover. With this method, the results vary according to who takes the measurements because people assess the situation subjectively. This leads to slightly different results, but with the SnowImager, such fuzziness disappears. Moreover, it measures the density of each layer and the data it provides is therefore more detailed.

The SnowImager still weighs five kilograms, but in the future, it should become handier and lighter, and thus suitable for everyday use – and ready for series production. Davos Instruments would like to produce the SnowImager locally. The project team believes there will be a demand in the long term for up to six hundred units in Switzerland alone, and talk about having the first portable and, at the same time, affordable device for measuring layers in the snow. The target group includes not only the avalanche warning services. Experts who determine when and where floods are imminent take into account the structure of the snow cover. Climate researchers can gain insights into climate change. Professional athletes use the data to help them choose the right equipment.

At the end of their day out measuring, Lars and Benjamin still have another strenuous task to do. They have to painstakingly fill in the hole they dug again. As Benjamin explains: "We wouldn't want a free-rider to fall in it and get hurt." *(job)*

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