IMPROVING SNOW AVALANCHE FORECASTING

We solve the problem of complete snow avalanche activity monitoring in forecasting regions in Norway by automatically detecting snow avalanches in radar satellite data provided by Sentinel-1 satellites.

The challenge

Snow avalanches (hereinafter called avalanches) pose a threat to people and infrastructure in Norway. Daily, public risk assessments (so-called avalanche forecasts) are carried out for large forecasting regions. A defining parameter of avalanche hazard is avalanche activity, i.e. how many avalanches of which type and size release in a certain area during a certain time period? This seemingly easy question is impossible to answer with traditional, field-based observation techniques. This is where the benefit of radarsatellite data comes in, providing the opportunity to detect avalanches consistently during a winter within a forecasting region.

The space based solution

The Sentinel-1 radar satellites provide daily images over Norway. Their free availability, high spatial resolution, large ground swath and all weather, all light capabilities make them perfect observation tools of avalanches. Avalanche debris, the depositional part of avalanches is detectable in SAR images owing to their rough surface reflecting more energy and thus supplying more information back to the satellites than the surrounding, undisturbed snow.

In our pre-operational service, we process all Sentinel-1 images over three forecasting regions in Norway and automatically detect all avalanches. About half an hour after the Sentinel images are available, the detected avalanches are stored in a geodatabase with a time stamp, location information and spatial extent. Forecasters of the Norwegian Avalanche Warning Service, who use the avalanche activity as an important information tool in their daily risk assessment, can access the database. During the winter 2016-2017, we increased the number of avalanche observations by a factor of ten, from about 900 field observations to over 12,000 satellite observations of avalanches.

Benefits to Citizens

Public, regional avalanche forecasts mainly target two user groups: Winter backcountry users, the group with the vast majority of avalanche fatalities, and public entities, responsible for infrastructure planning and road safety. Both user groups use the forecast as a risk reduction measure, depending greatly on its accuracy and predictive power. However, avalanche forecasting is inherently forecasting of uncertainty expressed in probabilities of avalanche release. Moreover, it is a complex, synoptic decision making task carried out by an expert. Our avalanche activity datasets decrease the uncertainty of the forecast, as released avalanches are the best available sign of prevailing avalanche hazard. This gives the forecasters an improved tool for their risk assessment and ultimately a higher quality avalanche forecast for the end users. The ultimate goal of an avalanche forecast is to prevent fatal avalanche accidents. Our service contributes to achieving this important goal.

3D view of a Sentinel-1 radar backscatter image with avalanches visible in the foreground in light grey.

Thematic Area: TRANSPORTS, CIVIL INFRASTRUCTURE AND SAFETY

Region of Application: ICELAND, ITALY, SWITZERLAND

Sentinel mission used: S1

Copernicus Service used: –

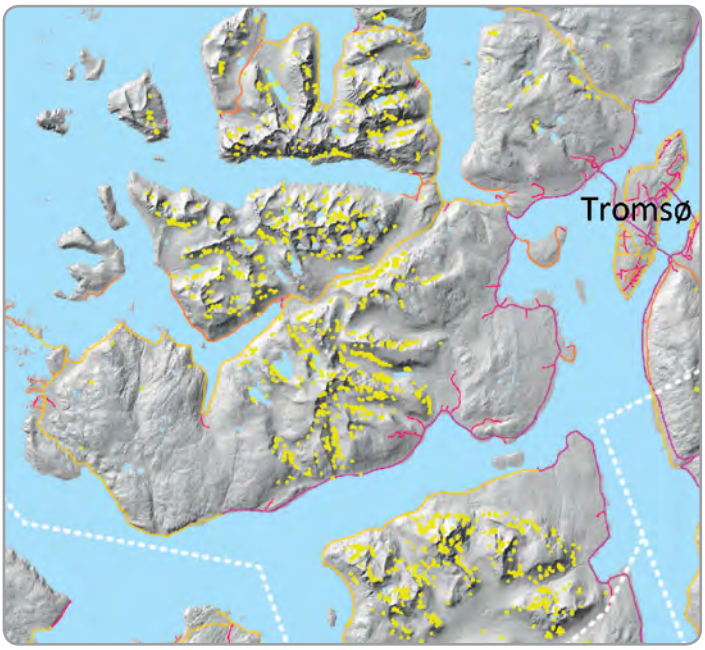
Usage Maturity Level: 4

Outlook to the future

From winter 2018-2019, our service will be transferred to the Norwegian Avalanche Centre thus becoming fully operational. Within the next two years, we plan to expand from the current three to all 22 forecasting regions in Norway.

With the worldwide availability of Sentinel-1 data, our service can be established in any avalanche forecasting region in the world.

Besides the monitoring service described, avalanche detections could also assist in emergency response situations in remote areas struck by extreme avalanche cycles. Lastly, the long-term collection of avalanche activity offers the opportunity to conduct climate-related studies



Map showing detected avalanches (yellow) during winter 2016-17 on the island of Kvaløya in Northern Norway
Credit: Contains modified Copernicus Sentinel data [2015]

> "Avalanche detections from radar satellite data decrease the uncertainty of our avalanche forecasts."

Rune Engeset,
Norwegian Avalanche Warning Service, NVE

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