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Avalanches in Longyearbyen Svalbard 2015 and 2017

Lawinen in Longyearbyen Svalbard 2015 und 2017

Abstract:
Longyearbyen, the administrative centre of the Svalbard archipelago, is facing most types of natural hazards under a changing Arctic climate. The first indication in meteorological data of a change in climate was a heavy rainfall midwinter 1995/96, years before global warming of the Arctic was documented.

The worst-case scenario in Longyearbyen will be a change towards present day Norwegian Coastal climate with corresponding large and more frequent geological processes. In December 2015 and in February 2017 avalanches hit buildings at the Lia residential area.

There were two fatalities in the 2015 incident and caused extensive structural damages in 2015 and 2017 incidents.

Keywords: Avalanches, Longyearbyen, Svalbard, Buildings, Fatalities

Zusammenfassung:
Longyearbyen, der Verwaltungssitz des Svalbard Archipels, ist den meisten Naturgefahren ausgesetzt, die im Zuge des sich ändernden arktischen Klimas auftreten können. Lange bevor die globale Erwärmung in der Arktis nachgewiesen werden konnte gab es schon die ersten meteorologischen Anzeichen des sich ändernden Klimas in Form von Starkniederschlägen im Winter 1995/1996.

Das Worst-Case-Szenario für Longyearbyen wäre eine Entwicklung des Klimas hin zu einem norwegischen Küstenklima mit großflächigen und immer häufiger auftretenden geologischen Prozessen.

Im Dezember 2015 und Februar 2017 waren Gebäude im Siedlungsgebiet Lia von Lawinen betroffen. Der Lawinenabgang 2015 forderte zwei Todesfälle und durch die Ereignisse beider Jahre entstanden beträchtliche Sachschäden.

Stichwörter: Lawinen, Longyearbyen, Svalbard, Gebäude, Todesfall

Introduction

Longyearbyen is located at 78° north and is an isolated town with approximately 2000 inhabitants during winter. The town was established in 1906 in a side valley of the wide Advent Valley in the centre of Spitsbergen. The site was chosen due to its close location to the coalmine that gave birth to the settlement. Buildings and houses have been moved in the valley from the location of one coalmine to another, but since the 1970's almost all new buildings were established close to the mouth of the valley. The available space for buildings and houses has always been limited to a small strip of land between the river and the mountains on both sides of the valley. The town is surrounded by steep mountain sides reaching up to almost flat plateau mountains. These plateaus give an almost endless fetch for drifting snow (Vogel et al., 2012).

This article is based on reports and articles written by NGI colleagues in the last year or so after the avalanche in 2015. Less information is available for the avalanche in February 2017 at the moment.

Climate

Longyearbyen is located in an arctic desert climate. The observed annual precipitation at the airport is less than 200 mm in the period 1976–2016. The climate on Svalbard has changed significantly in recent years. The annual mean temperature has increases by 3 °C since 1990. Especially the winter temperatures have increased with 2–3 °C per decade. This leads to more frequent warm spells with rain in the winter. In addition, the amount of precipitation has increased by 20–30 % in Longyearbyen since 1990 (Vikhamar-Schuler et al., 2016). There is generally little snow on the ground. The maximum snow height at the airport

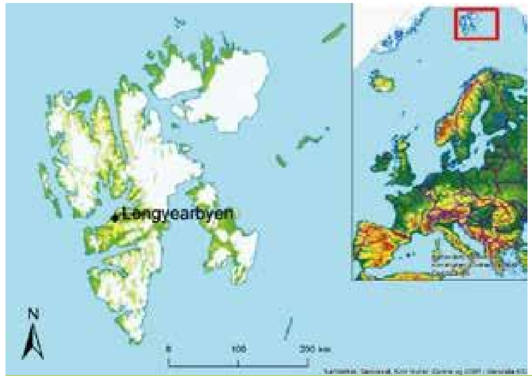

Fig. 1. Location of Longyearbyen in the Arctic.

Abb. 1: Lage von Longyearbyen in der Arktis

was 56 cm in 1986-04-26 (snow height data is missing 1995–2008). Due to the lack of vegetation, wind speeds are high and drifting snow is usually apparent (Jaedicke and Sandvik, 2002).

The avalanche accident on December 19th 2015

Weather

Starting on 17th December 2015 an intensive low pressure formed by two separate low pressures joining paths in the Norwegian Sea. The centre of the system increased in intensity while it moved towards the Svalbard archipelago. The low-pressure system was followed closely by the meteorologists and on the 17th December at 11:45 a first weather awareness warning was issued for the Svalbard Islands. The warning was "Spitsbergen: On Friday evening storm from east, night to Saturday possibly hurricane force. Locally gusts up to 40–45 m/s. Saturday morning decreasing wind, first in southern parts." The highest wind speeds were measured during the night from the 18th to 19th December. The lowest pressure of 966 hPa was measured on 19th December at 06:00.

The storm prior to the fatal avalanche

started on 17th December 2015 around 12:00 and ended in the morning of the 19th December, approximately three hours prior to the avalanche. Dominating wind direction was from east and wind velocities up to 25 m/s and gusts up to 30 m/s were measured at the airport. The mean temperature during the storm was -5.8 °C, with a maximum of -0.6 °C and minimum of -15.3 °C before the storm started. The temperature increased from -12 °C to -2 °C within 24 hours. The wind velocities at the mountain station Gruvefjellet were in the same range as at the airport. The valley station Adventdalen southeast of the town recorded the highest wind velocities with 26 m/s and with gusts up to 33 m/s.

The unofficial observed storm precipitation was approximately 30 mm, while the official record shows 18 mm in the morning on the 19th. Reliable snow precipitation measurements in these wind speeds are almost impossible. The meteorological forecast model HIRLAM 12 predicted a total of 45 mm for Friday 18th and Saturday 19th (Meteorological Institute, 2016).

Avalanche

The avalanche was released approximately at 10:24 in the morning of December 19th 2015. It was a dry-snow avalanche with a drop height of about 90 m and a run-out angle of only 16° released from the northern shoulder of Sukkertoppen above the outskirts of Longyearbyen. The fracture height exceeded 3 m at some points and was close to 2 m on average, giving a estimated release volume of 15,000 m³ and a fracture depth (normal to the terrain) of approx. 1.5 m. This was due to drifting snow under persistent strong southeasterly winds. The avalanche width was approx. 200 m and the maximum horizontal run-out approx. 300 m.

The avalanche hit eleven of the landmark "spisshus" (pointed-gable houses) from the 1970s and stopped against a few larger two-story houses to the southwest without damaging them. The four spisshus in the uppermost row were displaced by up to 80 m. In total, 19 persons were inside the houses during the event. Eight of them had to be hospitalized, an adult and a toddler died. Inhabitants of similarly exposed houses in Longyearbyen were subsequently evacuated. All eleven houses had to be dismantled afterwards.

Fig. 2.
The avalanche site during the rescue operation. Photo: Svalbardposten.no.

Abb. 2: Lawinengebiet während des Rettungseinsatzes.

The avalanche has been back-calculated with a dynamical model RAMMS::AVALANCHE v.1.6.20 to estimate the spatial pressure distribution. There are uncertainties about the snow avalanche density, the thickness and velocity. The first estimation of the velocity is that it might have been between 10 and 15 m/s when it hit the first row of houses and the density might have been between 100 and 200 kg/m³. The peak pressure would then have been 15–45 kPa (against wide solid walls).

Due to permafrost, most buildings in Svalbard are built on posts and horizontal wooden beams (the foundation). The "spisshus" are built of rigid segments and connected to the foundation with thin metal stripes. When the avalanche hit the buildings, it was relatively easy task for the avalanche to rip apart the metal stripes and displace the buildings.

The buildings suffered various degree of damage during the displacement. Table 1 gives an indication on the displacement, rotation and fatalities. It also gives "serviceability" of the building i.e. how well a building serves as a shelter for the residents when it is hit by rapid mass flows/movements (e.g. snow avalanches, slushflow, debrisflow, rockfall etc.). Our evaluation on "serviceability" is based on field a report which is short and incomplete. "Serviceability" is graded into five grades S1 to S5 or percentile where low percentile denotes "bad serviceability".

It is important to note that the victims were in the appendix/shelter between the rigid buildings when the avalanche hit. The shelters were much weaker construction than the main buildings. That might explain the why there were fatalities.

Bld. #	Location [line of houses]	Displacement [m]	Rotation Cw [°]	Fatalities	Serviceability [S/%]
Bld. no 36	1st	36	-6.1	1	2nd S1/90, 1st S2/80
Bld. no 34	1st	45	7.3	1	2nd S3/40, 1st S4/10
Bld. no 32	1st	54	-33.1	0	2nd S1/90, 1st S2/60
Bld. no 30	1st	82	-2.5	0	2nd S1/100, 1st S1/100
Bld. no 28	2nd	6	-5.7	0	2nd S1/90, 1st S2/60
Bld. no 26	2nd	13	7.1	0	2nd S1/90, 1st S2/60
Bld. no 24	2nd	15	-16.3	0	2nd S2/70, 1st S3/40
Bld. no 22	2nd	31	-7.7	0	2nd S1/100, 1st S2/80
Bld. no 20	2nd	55	NA	0	2nd S1/100, 1st S2/90
Bld. no 18	2nd	40	39.4	0	2nd S1/100, 1st S2/70
Bld. no 16	2nd	5	6.9	0	2nd S1/100, 1st S2/70

Here: 1st : first floor and 2nd : second floor. NA: not available.

Tab. 1. Overview over displacement, rotation and serviceability.

Tab. 1: Überblick über die Gebäudeschäden durch das Lawinenereignis 2015.

The avalanche accident on February 21st 2017

Weather

The period from February 5th to February 12th had warm weather and approx. 28 mm rain. On Feb. 12th the temperature fell and the precipitation was slush and snow. The period Feb. 13th to Feb. 20th was cold with temperature at lowest at approx. -21 °C. Between Feb. 19th and Feb. 20th there was a light snow fall but in the afternoon on the Feb. 20th the wind increased. The weather forecast for Longyearbyen for Tuesday Feb. 21st indicated strong easterly winds with some snow showers.

Avalanche

It is assumed that the initial release of the avalanche on the right in Figure 3 was at the top and the secondary release was in this rather shallow depression to the left (red area). The time of release of the avalanche to the left (release area from 2015) is not known. An avalanche release from the top of Sukkertoppen (e: Sugartop) (approx. 370 m above sea level) has been noted earlier by local observers but the avalanches stopped on a small shelf high up in the mountainside. Also in the lower elevations in the mountainside several smaller avalanches have been registered. Apparently, the avalanche in February 2017 was the first to reach all the way from top to bottom in this slope after the area was inhabited. However, some reports have indicated that a release from the mountaintop is possible.

There were no fatalities when the avalanche hit the buildings. It destroyed one building with three apartments but other buildings were almost intact (Figure 4).

Fig. 3: Avalanches registered on Feb. 21st 2017. The red areas are estimated to be the release areas and the green is registered path and run-out zone. The area on the left is almost the same area as avalanched in Dec. 2015. Photo taken Feb. 22nd 2017 by Arnt Rennan at the Governor's office (adapted from (NVE, 2017)).

Abb. 3: Dokumentiertes Lawinenereignis vom 21. Februar 2017. Die roten Flächen stellen die angenommenen Anbruchgebiete dar, die grünen Flächen den Lawinenpfad und die Auslaufzonen. Die linke Fläche ist fast identisch zu der aus dem Jahr 2015.

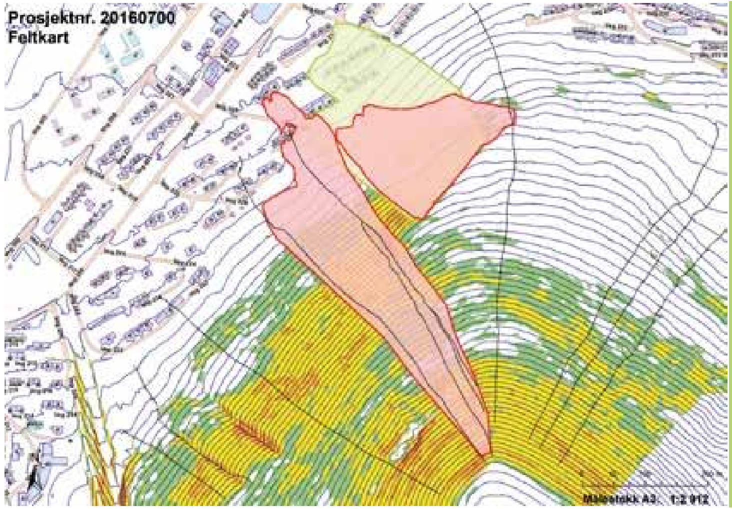

Fig. 4. Overview over the avalanches from Feb. 2017 (in red) and Dec. 2015 (light green). Black lines indicate fall-line (shortest line). Slope map: green indicates 27°–30°, yellow to red is steeper. Contour line equidistance is 5 m. Adapted from (NVE, 2017).

Abb. 4: Übersicht beider Ereignisse. 2017 in rot und 2015 in hellgrün. Die schwarzen Linien stellen die Falllinie dar. Hangneigungskarte: grün: 27° - 30°, gelb bis rot steiler. Höhenschichtenlinien im 5m-Abstand.

Epilog

Shortly after the avalanche in 2015, the authorities initiated a new hazard mapping work for several regions in Svalbard. The work was finalized in the fall 2016 and the hazard map was presented with three hazard zones i.e. annual nominal frequency 1/5000, 1/1000 and 1/100. The avalanche from Feb. 2017 reached the 1/5000 zone and the avalanche from Dec. 2015 is indicated to have return period between 500 and 1000 years. This information raises some questions about the validity of these maps.

The authorities have also initiated a mitigation work. The first phase is the avalanche site from Dec. 2015. Due to lack of apartments/houses for the inhabitants, the authorities want to reclaim the site, which was deemed hazardous after the avalanche. NGI has been awarded the contract to plan and design mitigation measures for the site.

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