NGI Technical note

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WP 2 – Full-scale experiments at Ryggfonn
Ryggfonn avalanche observations 2019/2020

Contents

Review and reference page

1 Introduction

NGI is operating the avalanche test site at Ryggfonn in Stryn municipality, Vestland county, western Norway (61.969°N, 7.275°E) since early 1980s.

In addition to the field work and data collection in frame work of WP2, necessary repairs and updating of the data acquisition system at the Ryggfonn avalanche test site were carried out under this task. This is to ensure that the site is ready for the winter season 2020/2021.

2 Research goals

A main challenge for avalanche research is to obtain a comprehensive understanding of the different flow regimes (dense, fluidized, or suspension flow) and of the involved physical processes. To obtain the necessary understanding, a combination of different measurements and observations is desirable to gain a broad and consistent picture of the avalanche flow. The understanding of complexity and variety of avalanche motion requires a combination of small-scale experiments (detailed investigations, statistics), large-scale tests (detailed investigation), and field observations (diversity, statistics). Cross-comparison between different avalanche paths (test sites) is necessary to uncover scaling relations, i.e. to identify differences in avalanche behavior arising from variations in total length or slope along avalanche paths.

Field observations and full-scale tests under controlled conditions are still necessary for the mentioned reasons and as a basis for statistical analysis.

3 Methods

NGI's operating the avalanche test site at Ryggfonn near Stryn since early 1980s (Gauer et .et. al. 2010; Gauer & Kristensen, 2016, and refences therein). The facilities at Ryggfonn consist of the main and secondary avalanche tracks with a vertical drop of 950 m, a catchment dam at the base, and several instrumentation installations for monitoring avalanche dynamics. The current facility is one of only two in the world of this scale, and the catchment dam is a unique feature making this location the only place in the world where the efficiency of avalanche mitigation can be studied in full-scale.

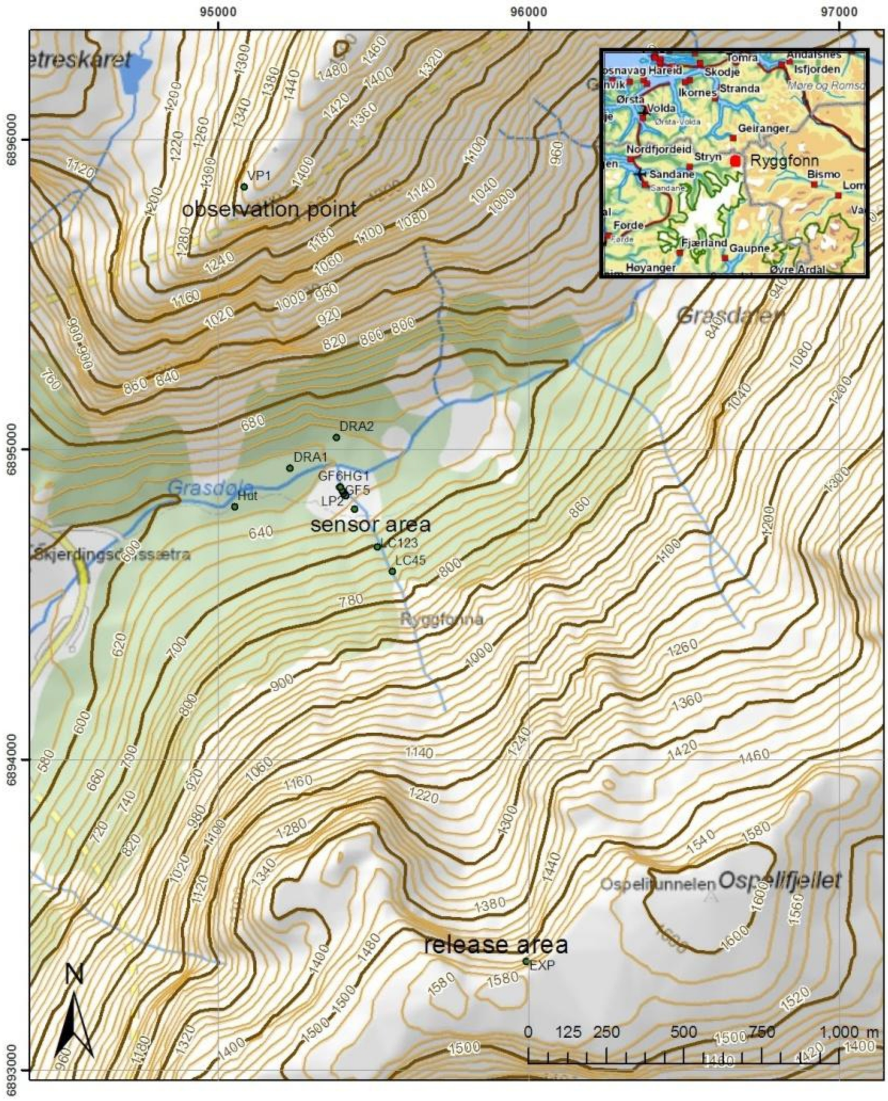

Figure 1 Map of the Ryggfonn test-site.

The NGI Ryggfonn facility was developed to obtain measurements to characterise avalanche dynamics and benchmark the development and calibration of numerical models. The full-scale testing facility was needed to investigate the complex dependency of avalanches on ambient conditions which cannot be reproduced in small-scale experiments. Data collected include velocity measures; impact pressure measurements, and flow height measurements at selected locations along the avalanche track. Field investigations are performed to collect runout data and data on mass balance. Corresponding meteorological data are measured at a close-by NGI station, Fonnbu.

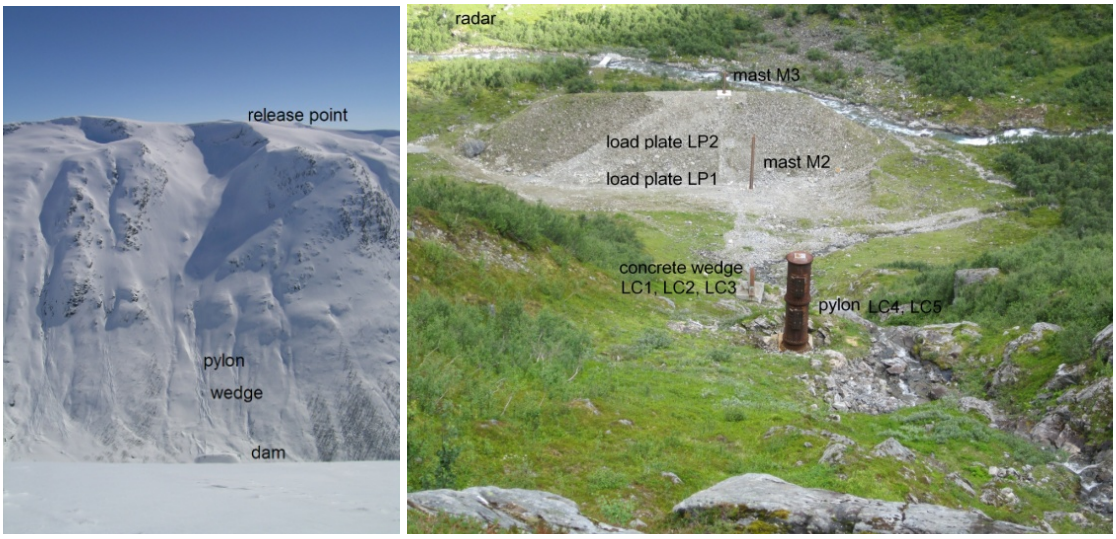

Figure 2 Existing NGI facility at Ryggfonn: (left) Avalanche track from the release area down to the retaining dam; (right) Example of sensor installations and full-scale pylon in the lower part of the avalanche track.

4 Results

Ten natural avalanches of size 2 to 3 (on the EAWS avalanche size scale) occurred during the winter 2019/2020. The avalanches released during end of December and beginning of January, in February, one in March and two early April. Due to Covid-19 restrictions, it was not possible to launch a field campaign in 2020. Nonetheless, the natural releases provided some pressure data and rough estimates on local velocities. Those events, however, showed again that it is desirable to have an autonomous RADAR system at the site to obtain velocity data and a system of time lapse cameras to obtain continuous information about the conditions before and after natural releases. Although field observations were carried out on few occasions after an event, the gained information were limited by weather constraints.

In this section a brief overview of the collected raw data is shown.

4.1 Weather data at the Fonnbu station

Figure 3 display an overview of major meteorological parameters throughout the season 2019/2020, with markers each month.

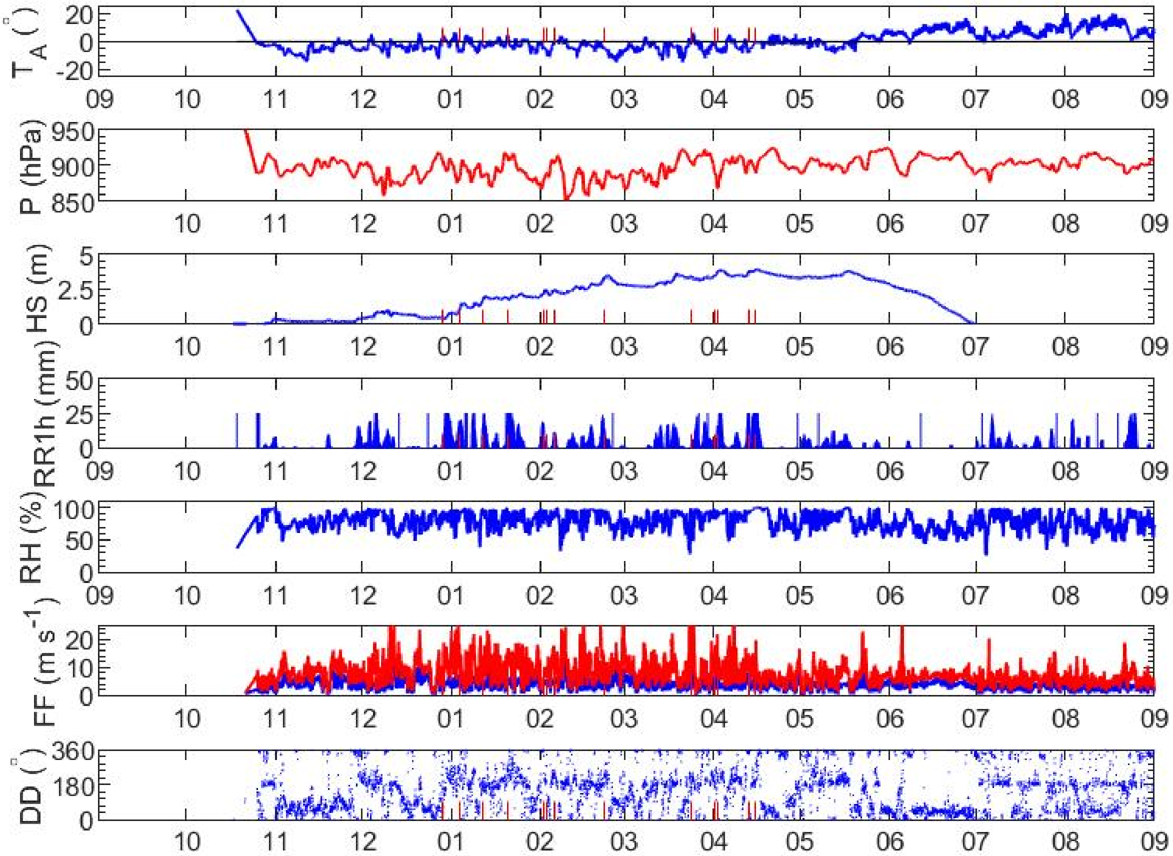

Figure 3 Overview of the major meteorological parameters (hourly data) during the season 2019/2020. The red stems in some of the plots indicate the date of the know avalanche event at Ryggfonn.

4.2 Observations at Ryggfonn

Table 1 Overview of natural avalanche release during 2019/2020; U_{LC} is the averaged velocity between the pylon and the concrete wedge.

Date (yyyymmdd)	time	U_{LC} (m/s)
20191229	NaN	NaN
20200104	00:50	16.2
20200111	21:09	NaN
20200120	12:00	5.3
20200202	07:23	NaN
20200203	06:49	NaN
20200205	16:11	17.0
20200223	01:26	46.0
20200324	13:53	31.0
20200401	14:40	NaN
20200402	10:01	28.0
20200413	14:28	16.2
20200415	16:55	NaN

Velocity estimates

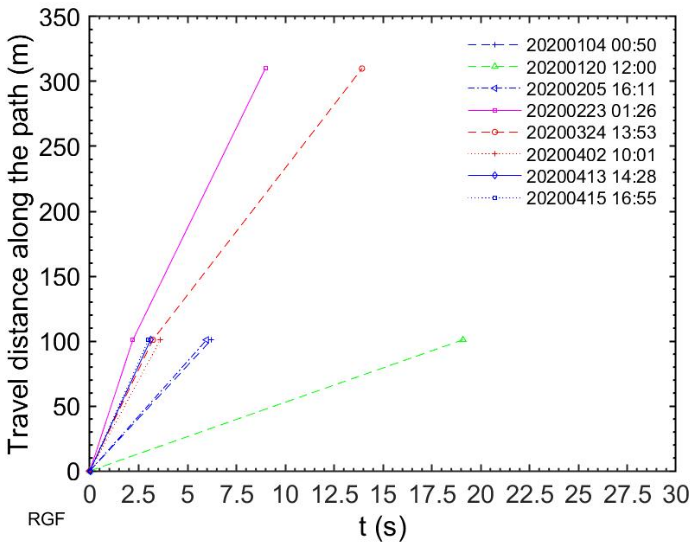

Figure 4 Timing of the avalanche. T=0 at the pylon, T1 at concrete wedge, and T2 at Mast #2(LC45, and LC123in Figure 1 and Figure 2).

Deposition area

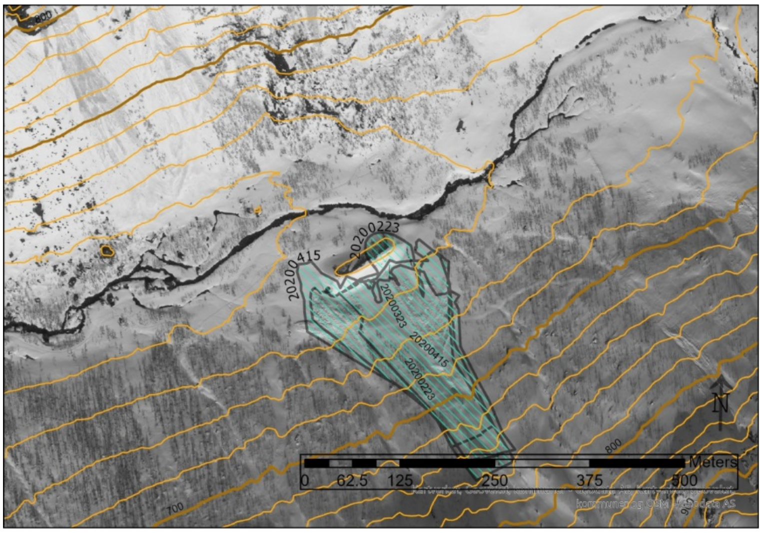

Figure 5 Deposition area of three natural avalanche events in 2020 based on brief field surveys; dates of the events are indicated.

2020-12-29T12:29

No useful data available

2020-01-04T00:50

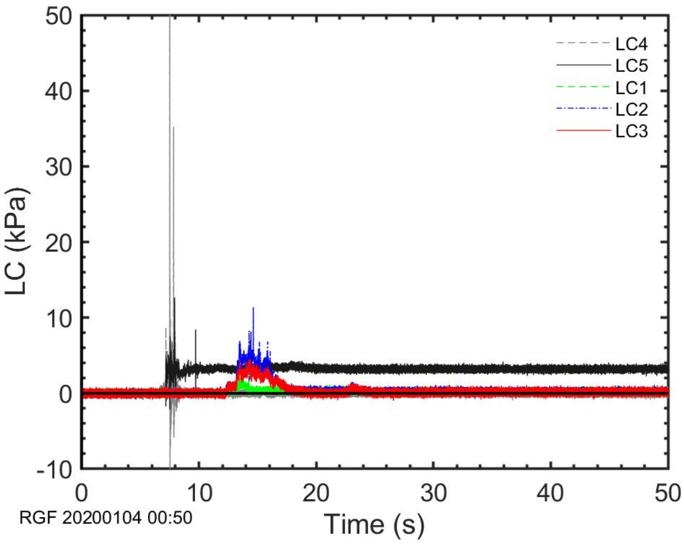

Figure 6 Load cell measurement: pressure vs. time at the position of the tower (LC45) and the concrete wedge (LC123).

2020-01-11T21:09

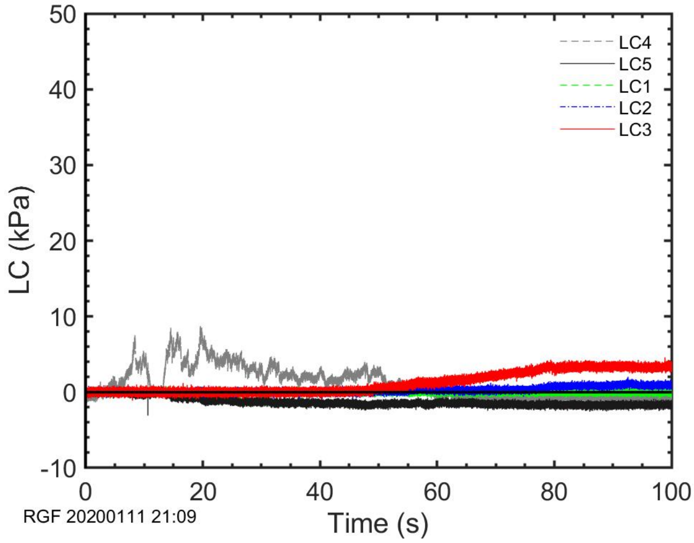

Figure 7 Load cell measurement: pressure vs. time at the position of the tower (LC45) and the concrete wedge (LC123).

2020-01-20T12:00

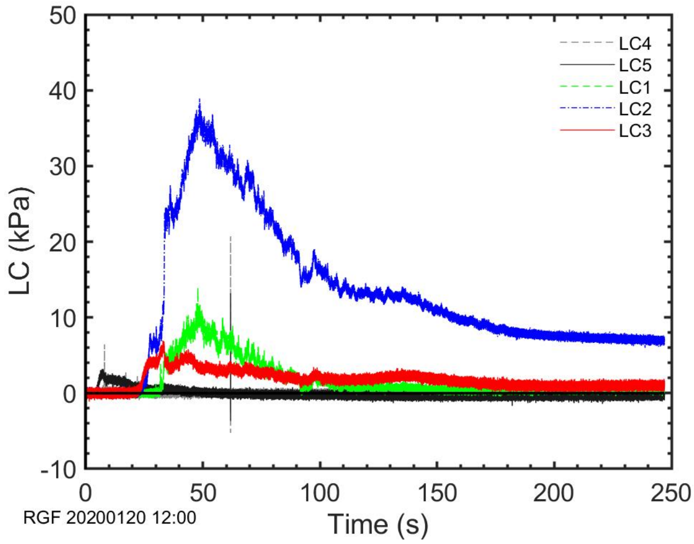

Figure 8 Load cell measurement: pressure vs. time at the position of the tower (LC45) and the concrete wedge (LC123).

2020-02-02T07:23

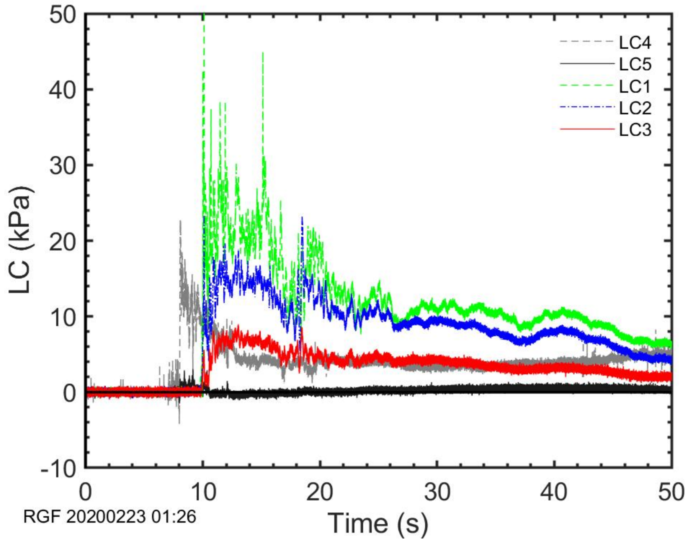

Figure 9 Load cell measurement: pressure vs. time at the position of the tower (LC45) and the concrete wedge (LC123).

2020-02-03T06:49

No useful data available

2020-02-05T16:10

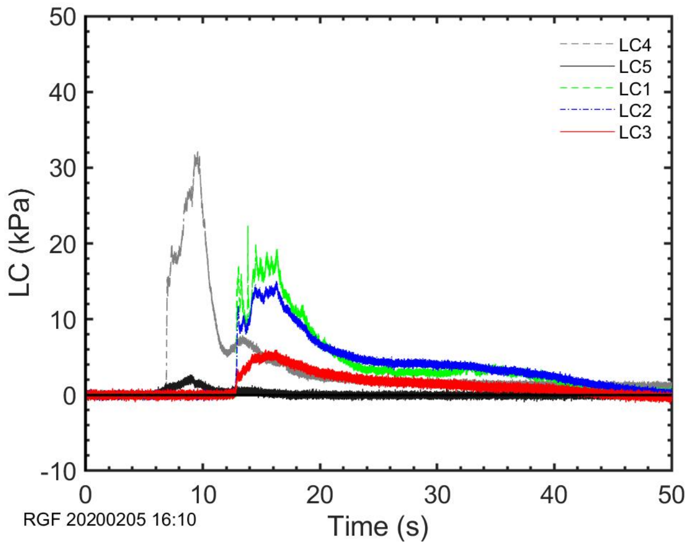

Figure 10 Load cell measurement: pressure vs. time at the position of the tower (LC45) and the concrete wedge (LC123).

2020-02-23T01:26

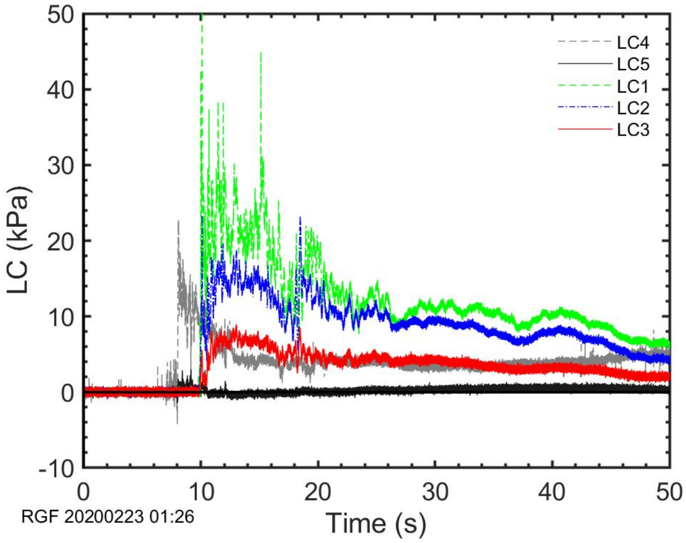

Figure 11 Load cell measurement: pressure vs. time at the position of the tower (LC45) and the concrete wedge (LC123).

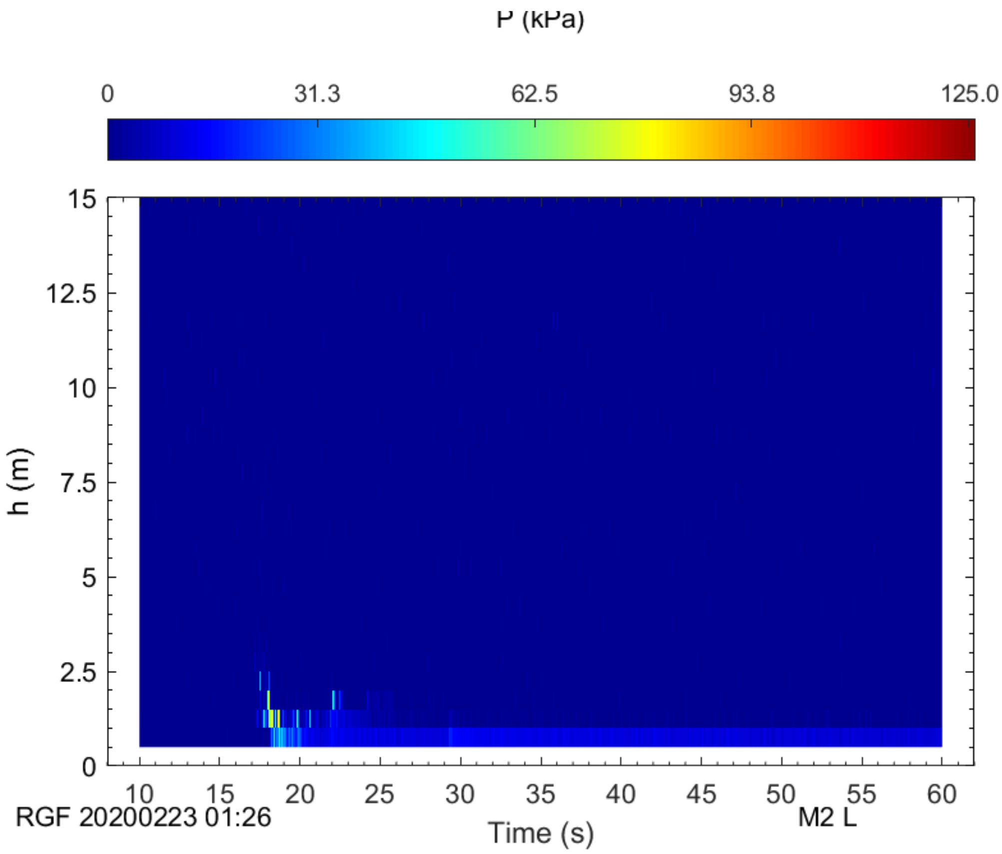

Figure 12 Load cell measurement: pressure vs. time at the position of Mast M2.

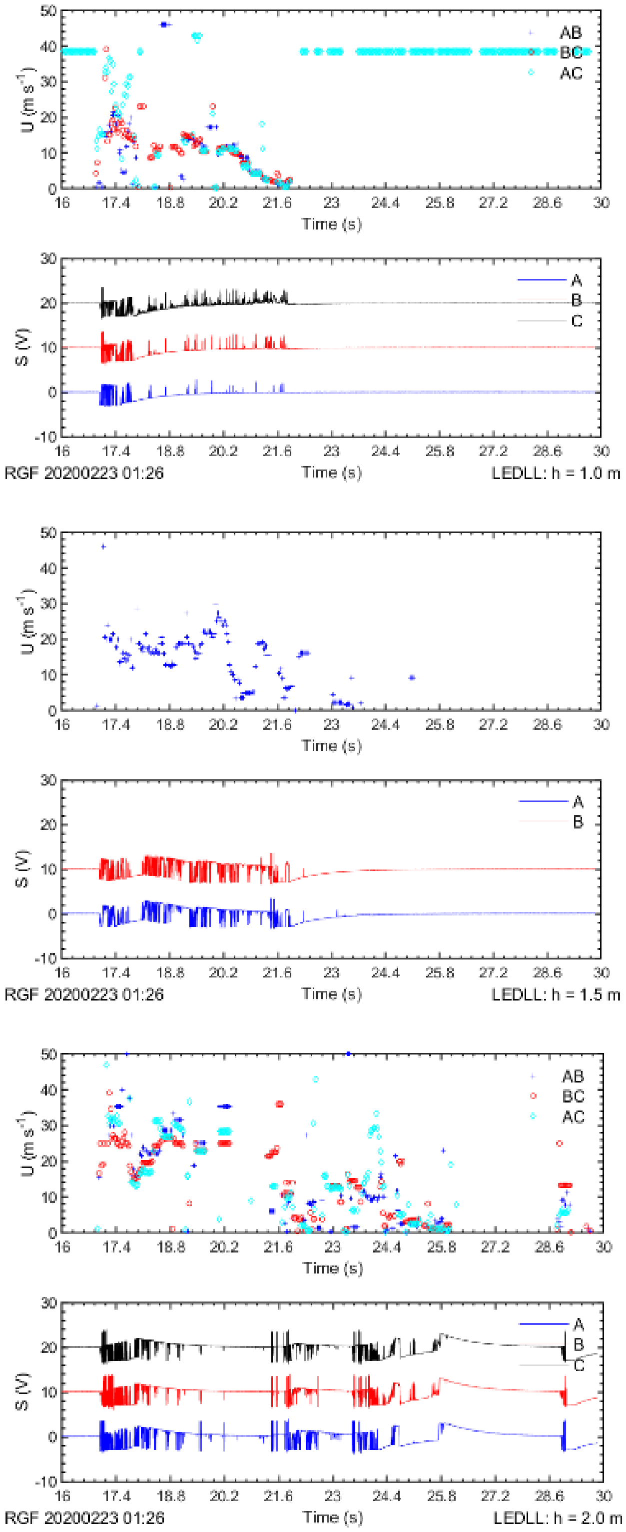

Figure 13 Preliminary velocity (U) estimates based on cross-correlated LED-data at 1.0, 1.5, and 2.0 m above ground. In addition, the raw data of the led-sensors are plotted.

Figure 14 Track of the 2020-02-23T01:16 event; photo taken on afternoon of 2020-02-26 (photos Henrik Langeland).

Figure 15 Back side of the dam after the 2020-02-23T01:16 event (photo Henrik Langeland 2020-02-26).

2020-03-24T13:53

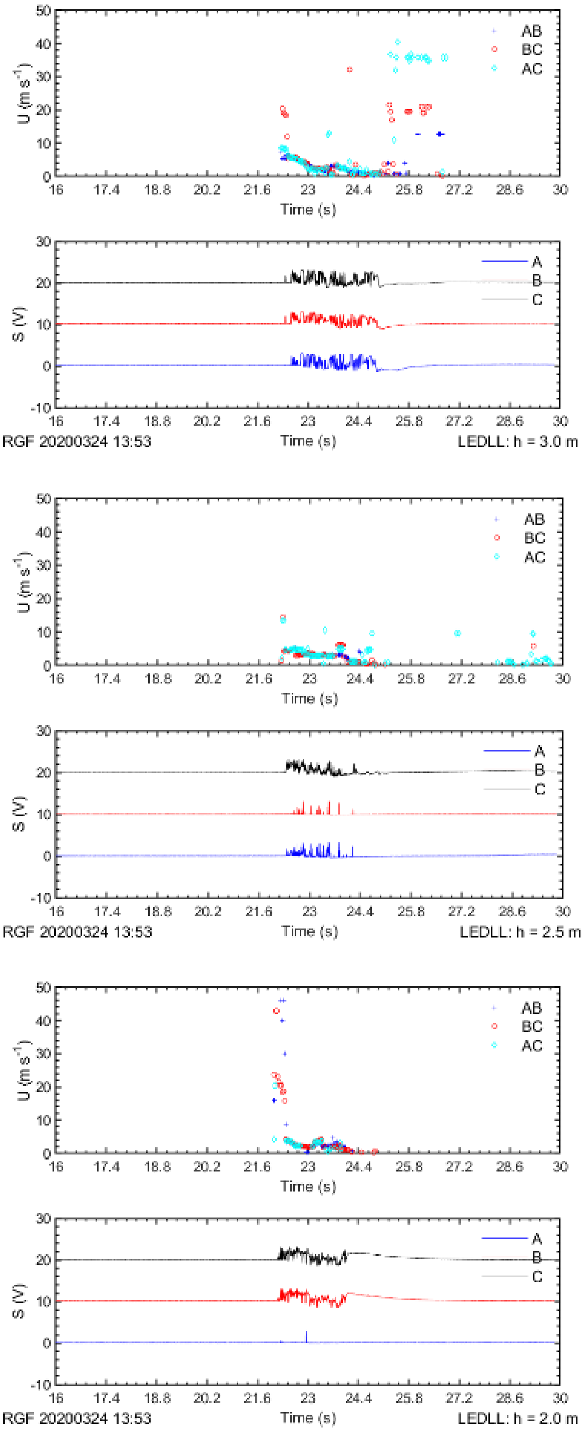

Figure 16 Preliminary velocity (U) estimates based on cross-correlated LED-data at 2.0,2.5, and 3.0 m above ground. In addition, the raw data of the led-sensors are plotted.

Figure 17 Deposition area of the 2020-03-24T13:53 event; photo taken on afternoon of 2020-03-26 (photos Henrik Langeland).

2020-04-01T14:40

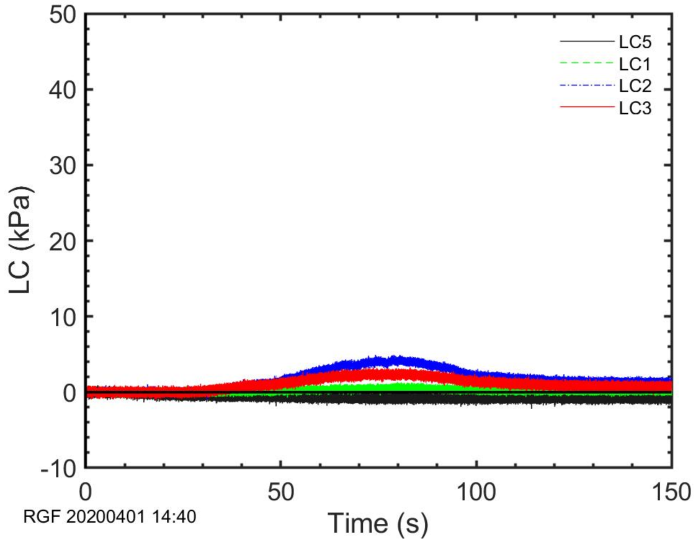

Figure 18 Load cell measurement: pressure vs. time at the position of the tower (LC45) and the concrete wedge (LC123).

2020-04-02T10:01

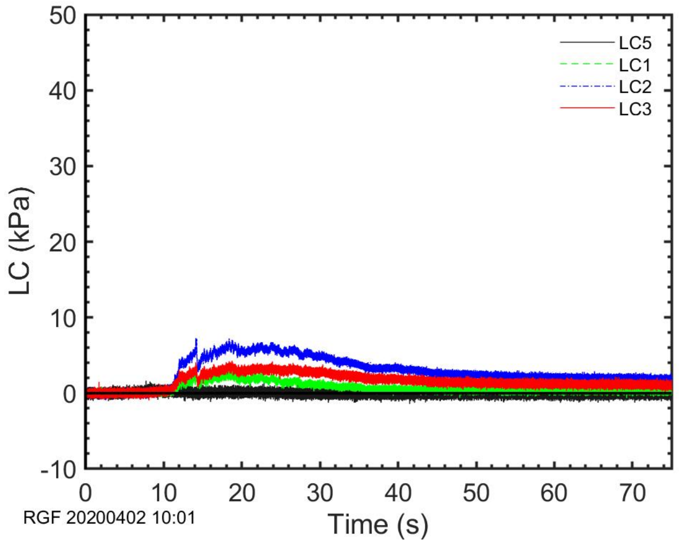

Figure 19 Load cell measurement: pressure vs. time at the position of the tower (LC45) and the concrete wedge (LC123).

2020-04-13T14:28

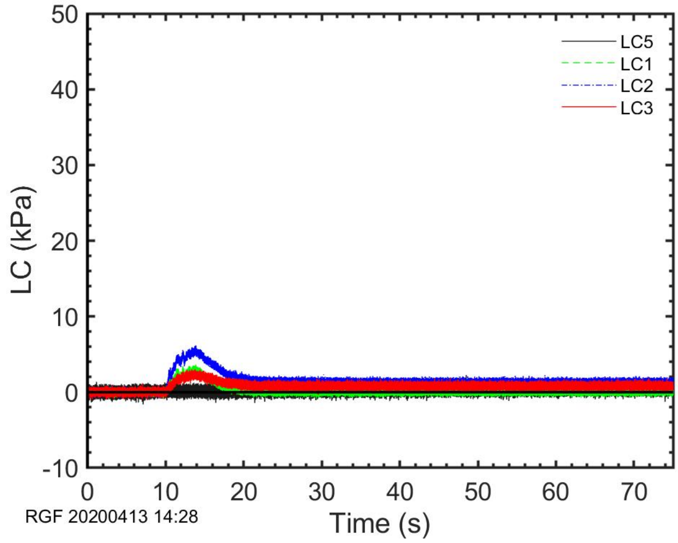

Figure 20 Load cell measurement: pressure vs. time at the position of the tower (LC45) and the concrete wedge (LC123).

2020-04-15T16:55

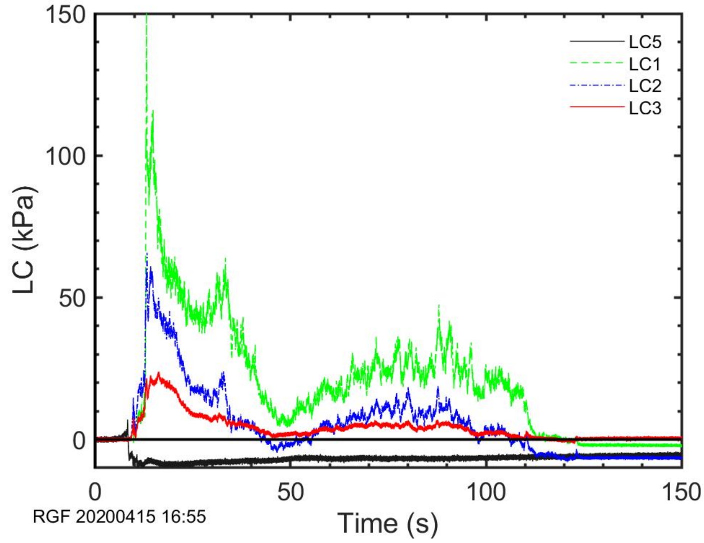

Figure 21 Load cell measurement: pressure vs. time at the position of the tower (LC45) and the concrete wedge (LC123).

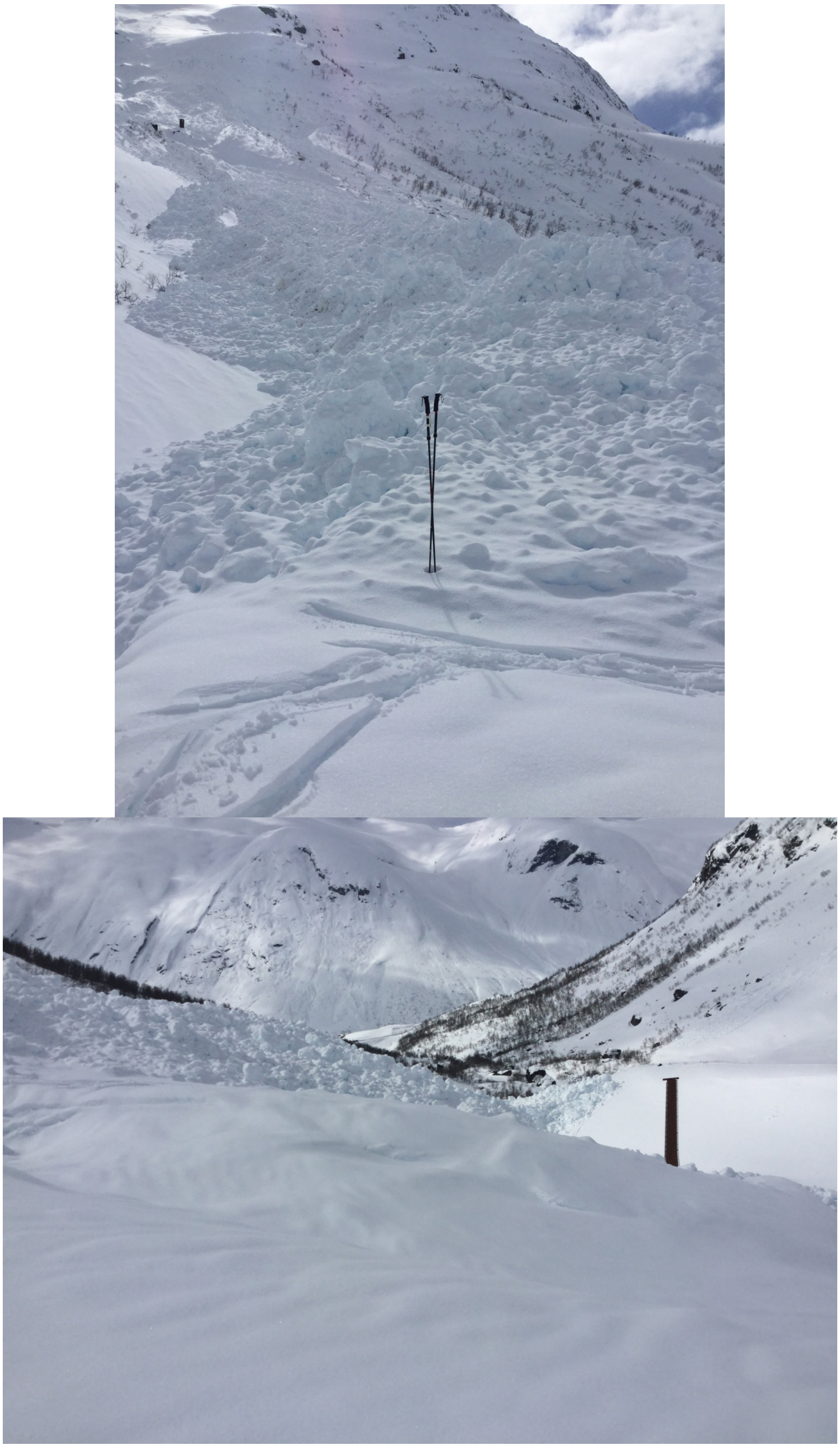

Figure 22 Deposition area of the 2020-04-15T16:55 event; photo taken on morning of 2020-04-18 (photos Henrik Langeland).

5 Concluding remarks

With financial means through GBV funds several upgrades at the Ryggfonn test site could be established or prepared this season. The updates include two small weather station at the top and at the valley bottom to have better information on the environmental conditions pre- and during avalanche release. This also includes a laser scanner for the release area. Secondly, the infrastructure for the installation of an autonomous pulsed Doppler radar was put in place. The radar is expected to be installed early 2021 in cooperation with BFW in Innsbruck, Austria, which offered a Doppler-RADAR systems for Ryggfonn.

6 References

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