



Inventory of glacier-related hazardous events in Norway

Miriam Jackson and Galina Ragulina

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Abstract: This report is a summary of known hazardous events and potentially hazardous situations related to glaciers in Norway. These are mainly due to jøkulhlaups, also called Glacier Lake Outburst Floods (GLOFs), ice avalanches and glacier length changes. Mountaineering accidents that occur on glaciers are also included in this report.

Key words: Glaciology, jøkulhlaup, GLOF, ice avalanche, glacier, icefall, glacier accident, mountaineering accident, glacier length change.

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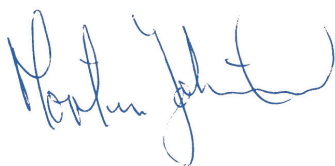
Preface

This report is a summary of known hazardous events related to glaciers in Norway, as well as a description of glaciers that are considered to be potentially hazardous. Most of the hazardous events registered on glaciers are jøkulhlaups, also called Glacier Lake Outburst Floods (GLOFs), and ice avalanches. Mountaineering accidents that occur on glaciers are also included in this report. Due to the nature of the subject this is not a comprehensive list, especially concerning mountaineering accidents, although we have made every effort to include the most significant events.

The work in this report originated in the European Union 5th Framework Project Glaciorisk (contract EVG1-2000-00512). Many of the incidents here are also included in the database that was created in the Glaciorisk project and that, as of November 2014, was still accessible at: <http://www.nimbus.it/glaciorisk/gridabasemainmenu.asp>.

Ole Magnus Tønsberg, Hallgeir Elvehøy, Solveig Havstad Winsvold, Nils Haakensen, Arve Tvede, Bjarne Kjølmoen, Rune Engeset and many others at NVE also contributed to the information in this report.

Oslo, November 2014



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1 Introduction

This report is a list of all known events that have occurred on or are due to glaciers in Norway. The most common events are jøkulhlaups, also known as glacier lake outburst floods (GLOFs), ice avalanches and incidents related to glacier length changes. Mountaineering accidents are also included here. Such incidents are generally not included in a report of this type; however, it was decided to include all incidents concerning glaciers in a common volume for completeness and ease of reference.

The location of each glacier is given as kommune (municipality) and fylke (county), as well as geographic coordinates. Many of the events listed here are from an outlet glacier of one of the large ice masses, such as Jostedalsbreen, Svartisen and Folgefonna, as well as events on smaller, discrete glaciers. The exact date is not known for all events – in these cases the month and year, or the year only, is given.

A total of 69 glaciers (76 glacier units) for which events have been recorded, or which are potentially dangerous, are listed here. There have been jøkulhlaups or glacier floods from 20 different glaciers (not including those that come under the category of glacier length change incidents, which have occurred at 12 glaciers). Of the 20 glaciers where jøkulhlaups have occurred, there are 12 that may cause jøkulhlaups in the near future as well as 8 additional glaciers which appear to have the potential for a jøkulhlaup to occur. Incidents classified as ice avalanches or due to a combination of ice avalanche and glacier length changes have occurred at 13 glaciers. Mountaineering accidents have been reported from 32 different glaciers. At least 35 fatalities are listed from 24 separate incidents. For some glaciers, e.g. Nigardsbreen, there are recorded incidents of different types. This report includes all incidents that have been studied by NVE, as well as other incidents in Norway that have been reported.

Glaciers that are considered potentially hazardous are also included in this report. This includes glaciers where a jøkulhlaup could occur, either due to recent glacier changes or where a hazard has always existed and although there are no records of a previous event, there is nevertheless a chance that such an event could occur in the future. There are no glaciers that are considered potentially dangerous in terms of a possible icefall in this list. However, almost every glacier is potentially hazardous in this respect if one approaches too close to the glacier front or margin.

The events are summarised in tables at the end of the report in several different ways for ease of reference – alphabetically by glacier name, chronologically by event and by event type.

The documentation included in this report was partially financed by the European 5th Framework research project GLACIORISK: Survey and Prevention of Extreme Glaciological Hazards in European Mountain Regions, No. EVG1-2000-00018. A similar report has been published for Switzerland (Inventar gefährlicher Gletscher in der Schweiz, Raymond et al, 2003)).

2 Event types

Event types are divided into four categories – jökulhlaup (J) or Glacier Lake Outburst Flood (GLOF), ice avalanche (IA), glacier length change (GLC) and mountaineering accidents (MA).

The first category, ‘jökulhlaup’, includes glaciers where one or more jökulhlaups have previously been documented, but where there is no longer any risk; those where recorded events have occurred and where it is thought that events could occur in the future and glaciers where there are no recorded events but where it is thought that an event could occur. Even though jökulhlaups in Norway are often directly connected to glacier length changes, we present them as a separate category because of rather complicated outburst mechanisms and sometimes catastrophic consequences.

Ice avalanches and glacier length changes are often related to each other, but not always. Glaciers are dynamic bodies of ice that are undergoing continuous change depending on past and present climate. Hence, the focus here is on rapid changes only, which have been a cause of damage or are potentially dangerous. An ice avalanche is often a direct consequence of a change in glacier length. For example, when a glacier front advances, the front generally becomes steeper and an ice avalanche is more likely to happen. The documentary evidence shows that the advance of glaciers is often associated with increased damage from landslides, rockfalls, ice avalanches and jökulhlaups (Grove, 1972 and 1988).

The mountaineering accidents category is simply all known mountaineering accidents that occurred on a glacier. This list is most likely incomplete as such events are not always reported.

The incidents documented here are from a variety of sources. Sometimes the location of an event is not clear, perhaps because of substantial changes in glacier geometry since an event occurred or because a local or incorrect name was used for a glacier rather than the “official” name. In this report, we have tried to correctly place such incidents but errors may have occurred. Some events are omitted from this list because there exists very little information about the actual event, or because the event reported does not fit with the location where the incident is said to have taken place.

2.1 Jökulhlaups

A jökulhlaup or Glacier Lake Outburst Flood is a sudden release of water from a glacier. The term in its most general sense refers to water from any of the following sources – a glacier-dammed lake, a pro-glacial moraine-dammed lake or water that was stored within, under or on the glacier. The term **jökulhlaup** is Icelandic in origin (from the Icelandic *jökull* = glacier, *hlaup* = flood). It originally referred to the well-known subglacial outburst floods from Vatnajökull, Iceland which are triggered by geothermal heating and occasionally by a subglacial volcanic eruption, but it is now used to describe any large and abrupt release of water from a glacier.

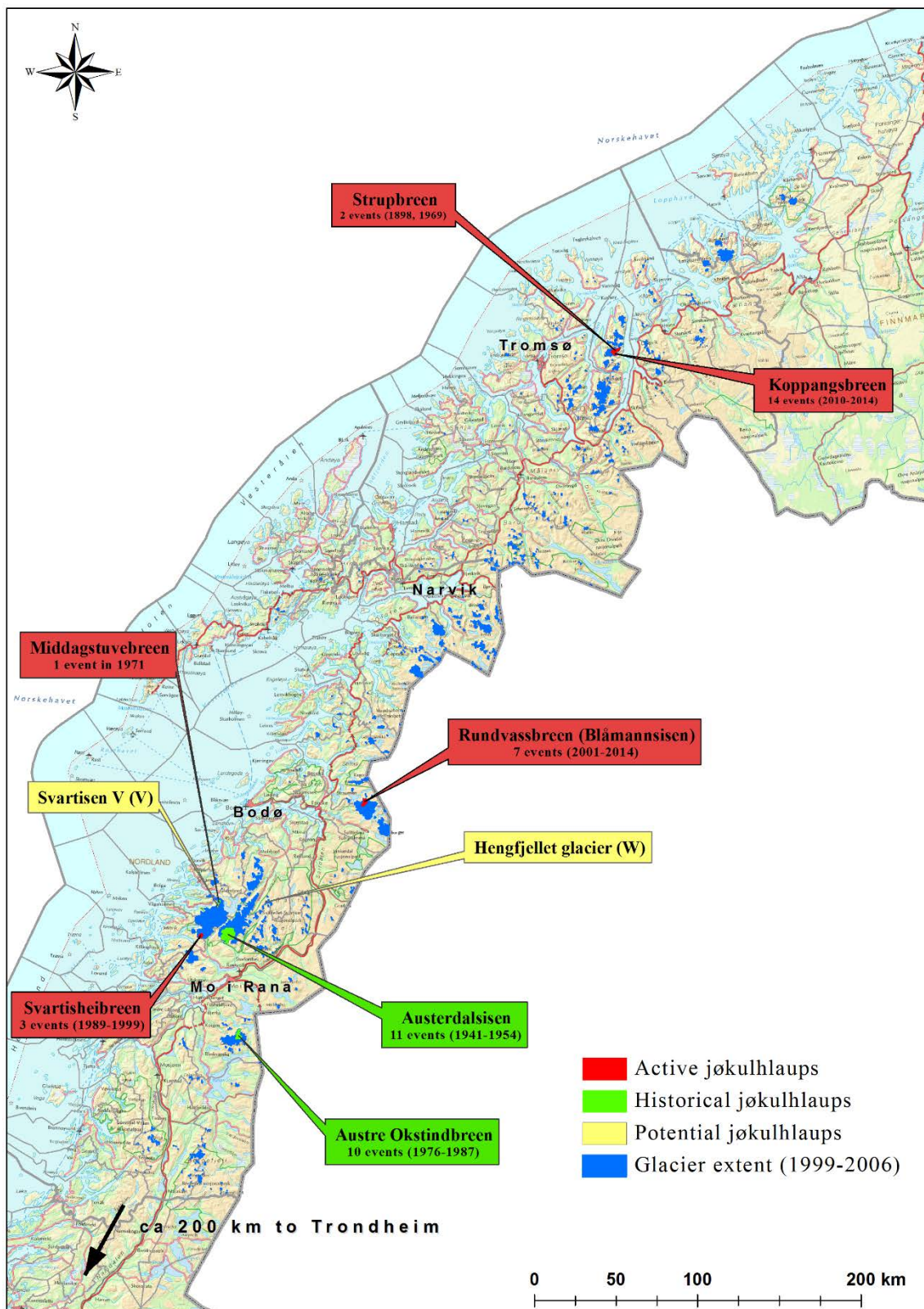
During such an event, the discharge from a glacier can increase by several orders of magnitude in a short period (e.g. Björnsson, 2002). Because of their far-reaching effect and their erratic nature, jökulhlaups pose a significant hazard and can cause substantial loss of human life as well as damage to agricultural land and infrastructure. Reviews of the geographic distribution and drainage characteristics of ice-dammed lakes are provided by Björnsson (2002).

Drainage from ice-dammed lakes occurs when the lake level is high enough to overcome a potential barrier at the glacier bed, thus enabling discharge underneath the glacier (e.g. Björnsson, 1974; Nye, 1976; Fowler, 1999). There are different mechanisms of flood initiation: some lakes start to drain when the water level reaches the flotation pressure of the ice dam, whereas others release their water at a lower level (e.g. Björnsson, 1992; Walder and Costa, 1996; Jóhannesson, 2002). In some cases, the water flows over the glacier as occurred at Rembesdalskåka, a glacier outlet of Hardangerjøkulen (Liestøl, 1956) in southern Norway.

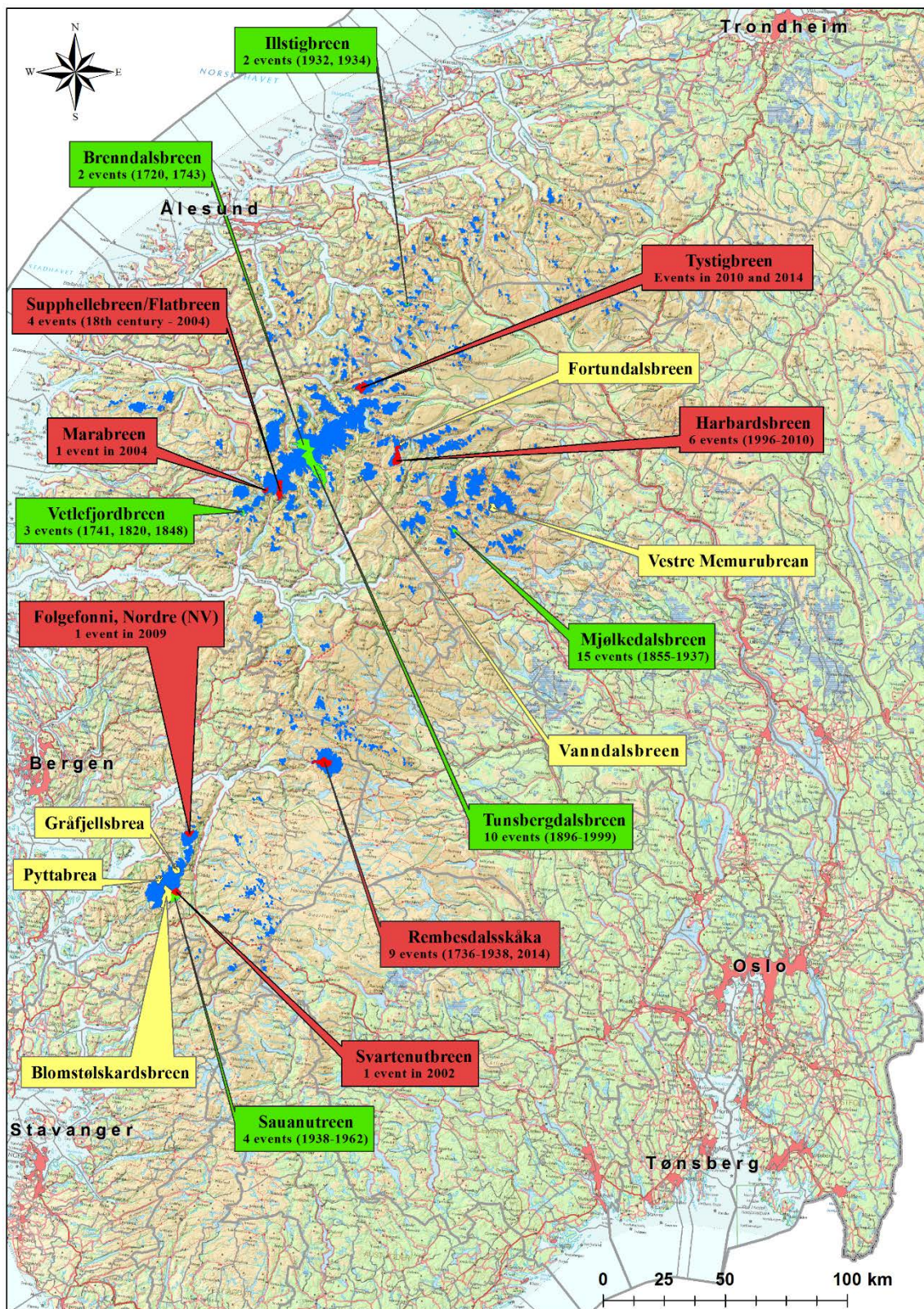
There are at least 20 glacier-dammed or supraglacial lakes in Norway, and several others existed previously but no longer exist (e.g. Brimkjelen at Tunsbergdalsbreen) [Map 1a,b]. The most dangerous jökulhlaups in Norway were from lake Demmevatn at Rembesdalskåka. Written sources describe late-summer jökulhlaups from this lake since the 18th century. After a catastrophic jökulhlaup in 1893, a rock tunnel was constructed to drain the lake artificially. However, a further decrease in glacier volume inflicted another two serious floods in 1937 and 1938 (Elvehøy and others, 2002). A new tunnel completed in 1938 lowered the lake an additional 50 m and a diversion tunnel was constructed in the 1970s for hydropower purposes. However, extensive thinning of the lowermost part of the glacier led to a new flood in summer 2014, the first since 1938.

Studies of jökulhlaups in relation to hydropower plants have been undertaken (e.g. Huggel and others, 2003), but tend to be focused on the hazards, rather than benefits. However, some knowledge of the possibility of reoccurrence in this case is useful not only in planning how to make the most efficient use of this additional water for hydropower, but also for risk mitigation (Engeset and others, 2005).

The potential drainage path of water from a jökulhlaup is shown for the relevant glaciers. In some cases different paths are shown (which could be in completely different directions) as the actual path depends very much on the bedrock topography underneath the glacier. For most glaciers a comprehensive study has not been performed, hence the path(s) shown is that considered most likely from the information available.



Map 1a – Glaciers with jökulhlaup events in Northern Norway. Svartisheibreen also had an event in 2014.



Map 1b – Glaciers with jökulhlaup events in Southern Norway.

2.2 Ice avalanches and glacier length change

2.2.1 Ice Avalanches

An ice avalanche or ice fall is a relatively comprehensive term that includes ice or ice and snow falling from a glacier in blocks, ice or ice and snow avalanches, debris avalanches from glaciers, ice pinnacles collapsing or ice falls due to water tunnels collapsing. It usually occurs from a glacier that is very steep.

The most serious type of ice avalanche is from a hanging glacier, as the ice can travel a long way and the danger may not be immediately obvious to those in the danger zone. Pralong and Funk (2006) proposed a classification of hanging glaciers, dividing them into different types according to the shape of the glacier itself, terrace or ramp, and according to the type of fracture, slab or wedge (see table 1).

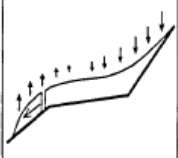
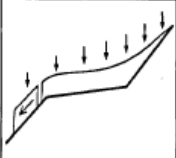
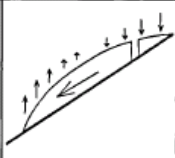
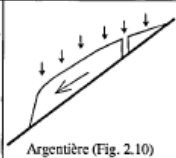
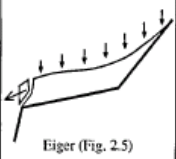
	Terrace		Ramp	
	Balanced	Unbalanced	Balanced	Unbalanced
Slab	 Allalin (Fig. 2.3)	 Balmhorn (Fig. 2.4)	 Coolidge (Fig. 2.8) Altels (Fig. 2.9)	 Argentière (Fig. 2.10) Weisshorn (Fig. 2.11) Jorasses (Fig. 2.12)
Wedge	balanced avalanching glaciers are not subject to wedge fractures		ramp glaciers are not subject to wedge fractures	
	 Eiger (Fig. 2.5) Gutz (Fig. 2.6) Mönch (Fig. 2.7)			

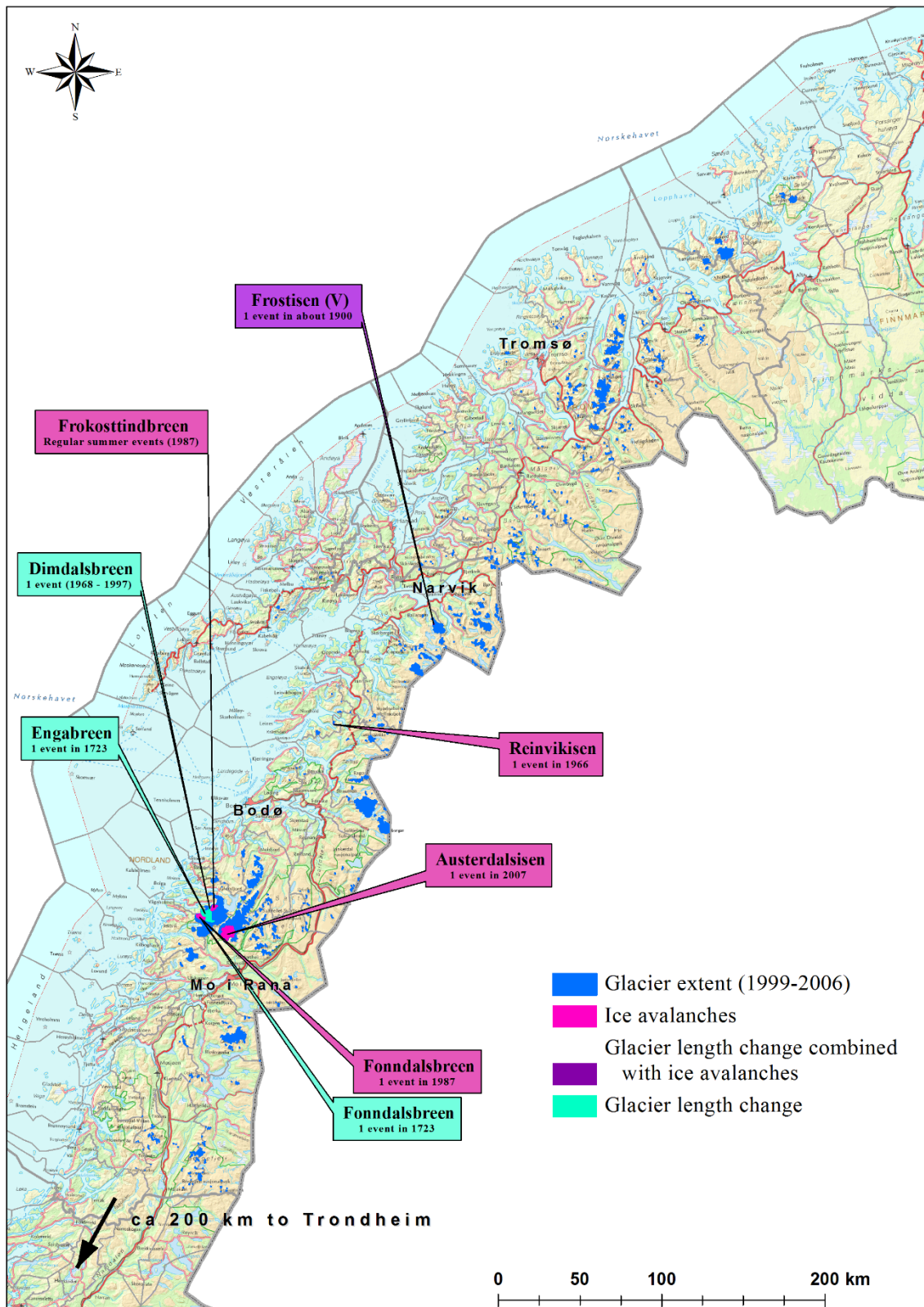
Table 1. Classification of avalanching glaciers, taken from Pralong and Funk (2006).

Ice avalanches are not as common as jøkulhlaups in Norway, but there have been some major incidents (such as that at Baklibreen in 1986) that have led to injury or fatalities. However, the most common type of ice avalanche occurring in Norway is a small event that occurs at the glacier front. Such an event consists of a relatively small volume of ice, which travels only a short distance. These occur continually in the summer and generally are not a problem, except when people are very close to the glacier. An ice avalanche can occur at the proglacial tunnel and block the water flow temporarily, leading to a minor jøkulhlaup when the water manages to burst through again.

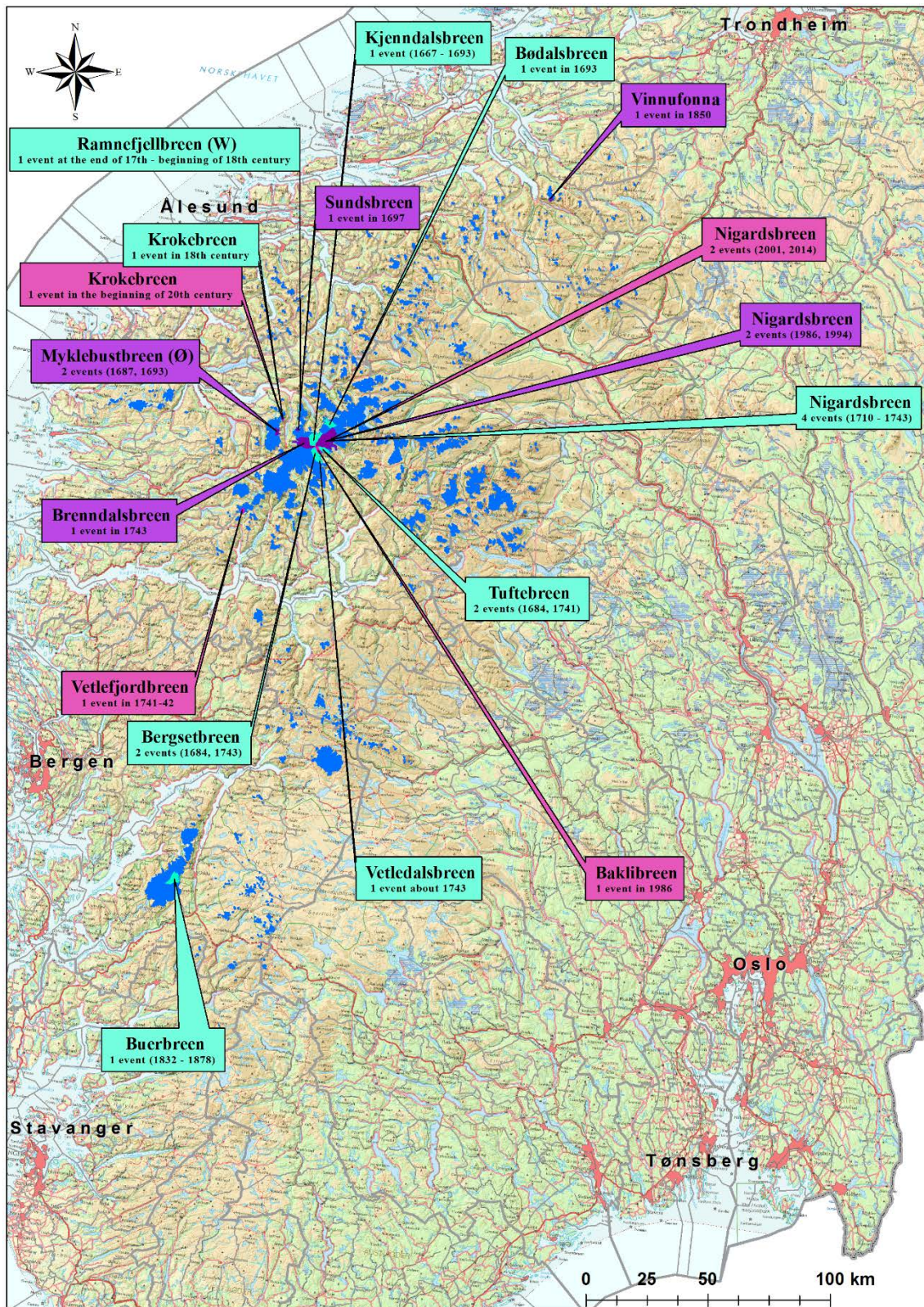
Ice avalanches are often closely related to glacier advances (see 2.2.2 Glacier Length Change, below).

2.2.2 Glacier length change

Glacier length change refers to events caused by an advancing or retreating glacier. If a glacier advances then the front becomes steeper, the number of ice avalanches from the front increases and the glacier can cover and destroy land that was inhabited or cultivated prior to the advance. A glacier advance may also dam an existing water body or cause pooling and this can then lead to a jökulhlaup. Glacier retreat often gives rise to moraine-dammed lakes that can subsequently breach the dam and cause a jökulhlaup.



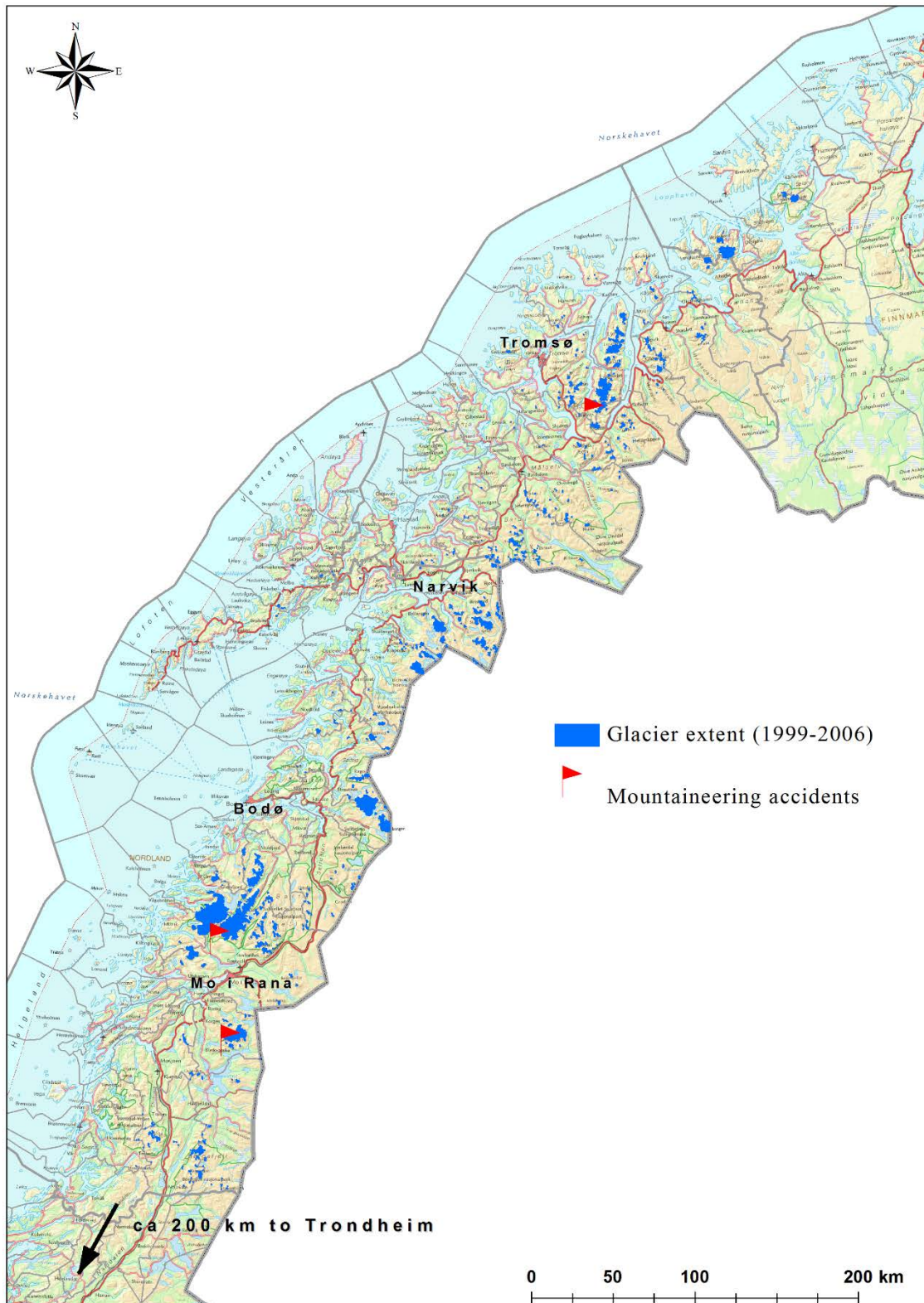
Map 2a – Glaciers in northern Norway where ice avalanche events have occurred and/or events related to rapid glacier length change.



Map 2b – Glaciers in southern Norway where ice avalanche events have occurred and/or events related to rapid glacier length change.

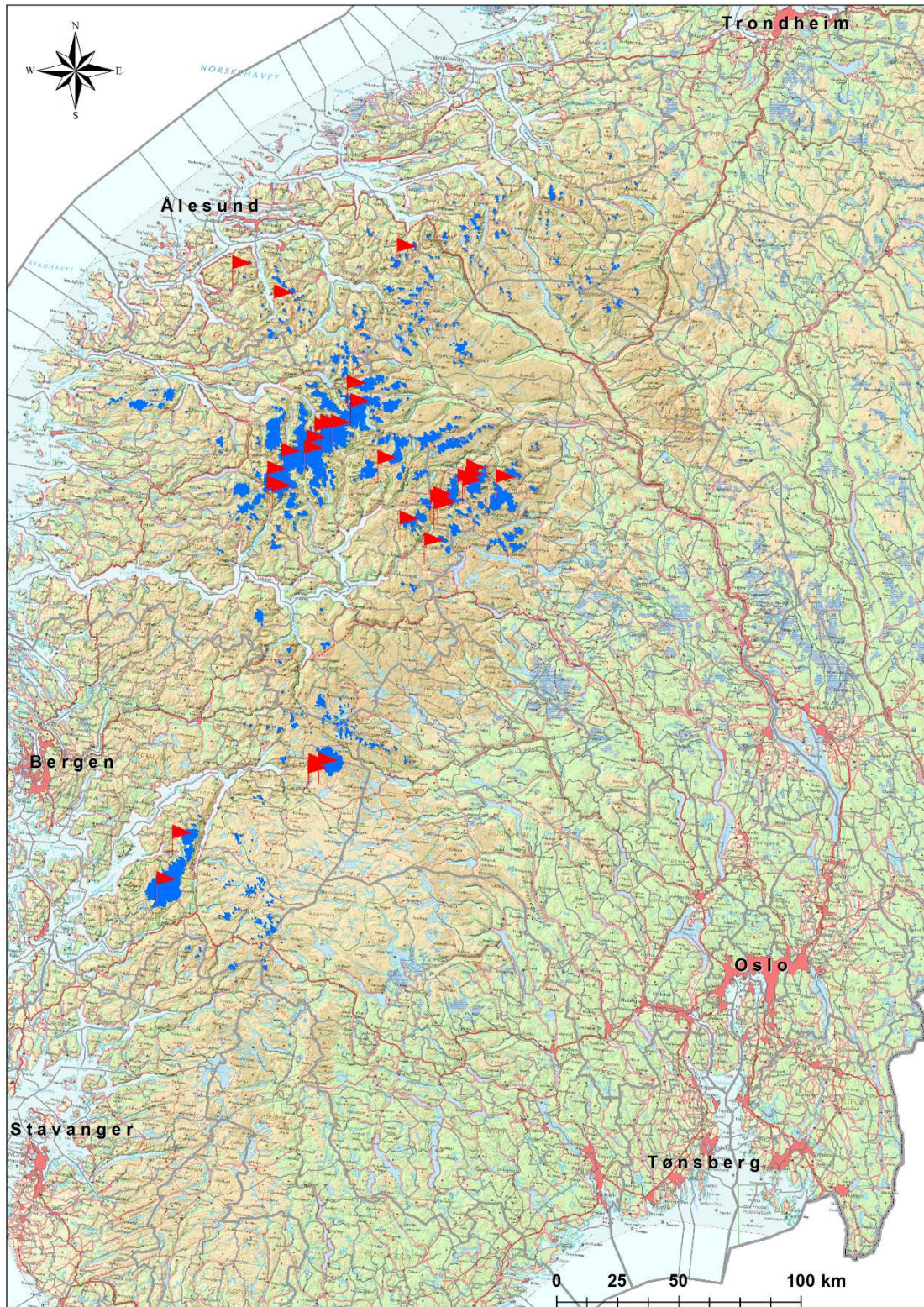
2.3 Mountaineering accidents

This category is not usually included in reports of this kind, but is included here so that all incidents related to a certain glacier are documented in the same report.



Map 3a – Glaciers in northern Norway where mountaineering accidents have been registered.

Mountaineering accidents are accidents that happen on glaciers during trips involving walking, skiing, hiking or climbing. Most incidents are a fall into a crevasse, improper use of equipment or accidentally sliding on snow and ice. Although we attempted to include all known events, this list is probably incomplete due to its very nature.



Map 3b – Glaciers in northern Norway where mountaineering accidents have been registered.

3 Catalogue of events

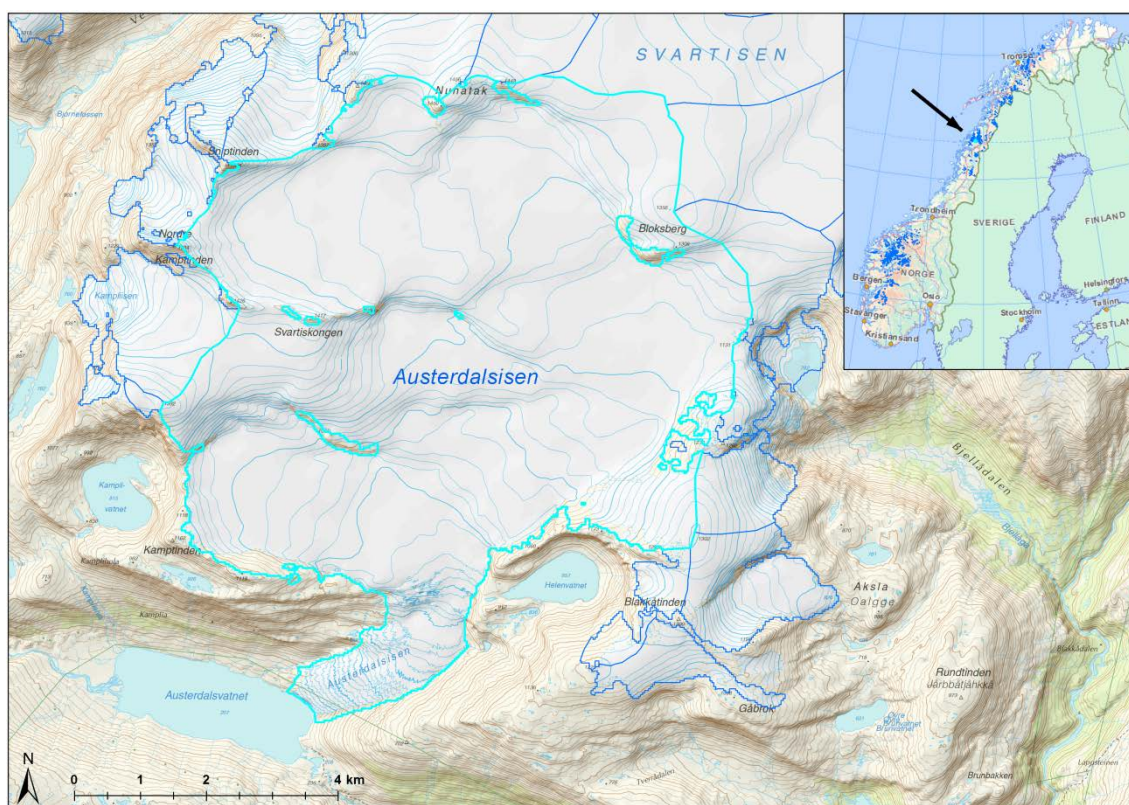
This chapter is a list of all known events on glaciers in Norway. The events are listed according to glacier, so some glaciers have many events listed for them. Information includes the glacier location ('kommune' or municipality, as well as latitude and longitude), the glacier ID in the World Glacier Inventory and the glacier ID in the recently published Inventory of Norwegian Glaciers (Andreassen and Winsvold, 2013) as well as physical aspects of the glacier (area, length, altitude, glacier type). The type of event is given – jøkulhlaup, ice avalanche, glacier length change or mountaineering accident and a description is given for each event where this information is available. Certain incidents are well-documented, whereas for others there is very little known.

Some of the glaciers are presently being monitored or were monitored for a period after an incident had occurred. Future risk is also included, but this is not always well-known and for most of the glaciers here has not been thoroughly investigated. The actual risk may also change considerably if the glacier characteristics change.

Austerdalsisen

Location:	Rana, Nordland. Latitude: 66.57° N, Longitude: 14.14° E
WGI-ID:	N4A000CX033
NVE-Atlas-ID:	1361
Dimensions:	Area: 55.41 km ² , length: 16.1 km
Altitudinal range:	208 – 1562 m a.s.l.
Glacier type:	Outlet glacier
Event type:	Jøkulhlaup, Mountaineering accident, Ice avalanche.

Description: Austerdalsisen is an outlet glacier draining southwest from Østre Svartisen icecap. It is the largest single glacier unit in Norway. Austerdalsisen ends in Lake Austerdalsvatnet, which is the largest known post-glacial glacier dammed lake in Norway. From 1941 to 1954 there were almost annual jøkulhlaups from this lake and east into Lake Svartisvatn and thence to the River Rana.



Map: Norge digitalt



Austerdalsisen photographed on 24th August 2001. Photo: Bjarne Kjølmoen, NVE.

The pre-jøkulhlaup drainage from Austerdalsisen was a western outflow down to Glomdalen. Only a small stream flowed into Svartisdal, with fairly clear water for a glacial stream. The main river, however, carried a lot of sediment.

Events:

1941 – 1954 – Jøkulhlaups from Lake Austerdalsvatn to lake Svartisvatn and river Rana. Usually during July and August. Volumes:

1941 – 30 mill m ³ .	1946 – 56 mill m ³ .	1950 – 120 mill m ³ .	1954 – 150 mill m ³ .
1942 – 52 mill m ³ .	1947 – 82 mill m ³ .	1951 – 132 mill m ³ .	
1944 – 38 mill m ³ .	1948 – 92 mill m ³ .	1952 – 113 mill m ³ .	
1945 – 45 mill m ³ .	1949 – 85 mill m ³ .	1953 – 136 mill m ³ .	

22/07/1986 – Mountaineering accident. Two people fell into a crevasse; one died and the other was injured (Finnmark dagblad 23/07/1986, Aftenposten 23/07/1986, Nordlands Framtid 25/07/1986, Nytt fra Norge 28/07/1986).

18/07/2007 – Ice avalanche at the tongue of Austerdalsisen caused the death of a 51-year-old Czech tourist. Details of the accident are unclear but it is thought he was part of a group of about 50 Czech tourists who were standing near the glacier front when an icefall occurred. The man was buried under a large ice block, which was later removed with help of a helicopter. A female member of the same group sustained head and arm injuries and was transported over Svartisvannet lake by boat to an ambulance and further to Rana hospital (RanaBlad.no 18/07/2007 (H.C.Hansen), P4.no 18/07/2007 (K.M.Habberstad), NRK 18/07/2007 (O.R.Haraldsen&A.A.Haraldsen), Nordlys.no 18/07/2007, Helgeland-Arbeiderblad 18/07/2007 ((H.C.Hansen)).

06/07/2014 – Mountaineering accident. A 17-year old man from Mo i Rana sustained a serious head injury and was unconscious after he fell about 20 m from the ice of Austerdalsisen glacier. He was accompanied by a female friend on a walk along the western side of Svartisvatnet lake and up to the glacier. The man was transported to hospital in Bodø by helicopter several hours after the accident (RanaBlad.no 07/07/2014 (E.Wie)).

Monitoring: Austerdalsisen was studied as early as 1873 by De Seue (De Seue, 1876) who carried out measurements of velocity on the eastern glacier outlet and took a number of

photographs. Subsequently Rabot, Rekstad, Marstrander and Granlund visited the glacier, but they were principally interested in the eastern branch towards Svartisdal. In later years, after the first floods from glacier lake Austerdalsvatnet, the western part and the lake were given more attention. G. Holmsen visited the lake in 1949 and discussed the conditions at the glacial lake and the devastating effects of the jøkulhlaups (Liestøl, 1956).

NVE has monitored discharge from the lake and changes in the lake and glacier since the 1940s.

Olav Liestøl made a glaciological study in 1949 and 1954, and constructed a map from photogrammetry of the glacier.

Recent photographs taken 1997, 2001, 2003.

Detailed map surveys performed in 1945, 1954, 1968, 1979, 1985.

Future risk: Due to glacier retreat and construction of a tunnel to the lake in the 1960s, there is no longer any risk of jøkulhlaups under present glaciological conditions.

References: Aftenposten 23/07/1986, Finnmark dagblad 23/07/1986, Helgeland-Arbeiderblad 18/07/2007, Nordlands Framtid 25/07/1986, Nordlys.no 18/07/2007, NRK 18/07/2007, Nytt fra Norge 28/07/1986, P4.no 18/07/2007, RanaBlad.no 18/07/2007, 07/07/2014.

De Seue, C. 1876. Undersøgelse af Svartisen og temperaturforhold i enkelte af de Nordlandske fjorde. *Nyt. Mag. for Naturvidenskab*. Bind 21, 1876.

Holmsen, G. En ny bredemt sjø i Svartisen. *Norsk Geografisk Tidsskrift*. Bind 12, 1949.

Liestøl, O. 1956. Glacier Dammed Lakes in Norway. *Norsk geografisk tidsskrift nr. 3-4*. Bind XV, 1955-1956, h. 3-4.

NVE glacier database, Norge digitalt.

Austre Okstindbreen

Location:	Hemnes, Nordland. Latitude: 66.01° N, Longitude: 14.30° E
WGI-ID:	N4A000CW002
NVE-Atlas-ID:	1438
Dimensions:	Area: 14.14 km ² , length: 7.0 km
Altitudinal range:	772 – 1764 m a.s.l.
Glacier type:	Outlet glacier, valley glacier
Event type:	Jøkulhlaup, Mountaineering accident

Description: Austre Okstindbreen is a northeast-facing outlet glacier from Okstindbreen ice cap (the eighth largest glacier in mainland Norway) and is a typical valley glacier. The glacier is divided into two parts by an icefall between 1000 and 1200 m a.s.l. In the lower part (below 1200 m a.s.l.) the surface is uneven with crevasses and exposed ice in the summer. A scene from www.norgebilder.no (next page) shows a supraglacial lake on the glacier about 800 m southeast of the mountain peak Okskalvan.



Map: Norge digitalt



Photo: Kjell Harald
Nesengmo (17/08/2011) –
glacial tongue



www.norgebilder.no (04.07.2009) – supraglacial lake.

Events:

1976 – 1987 – Jøkulhlaups from lake Leirskardsvatnet:

31/07/1976 – 0.34 mill. m³

19/07/1982

05/08/1977

29/07/1984 – 0.36 mill. m³

August 1978

July 1985

30/06/1979

July 1986

August 1979

16/07/1987

11/08/2006 – Mountaineering accident. A man fell into a crevasse when crossing the glacier tongue on his way from Kjensvatnet to Oksskolten. He had no glacier safety equipment. His companion called for assistance, and he was rescued by personnel from Rescue helicopter service (330 squadron, Bodø) with minor injuries and hypothermia (Helgeland Arbeiderblad, journalist Ole Martin Loe, 11/08/2006).

2/08/2011 – Mountaineering accident. A 22 year old woman fell into a crevasse close to the summit of Oksskolten in Hemnes municipality. She was on a walking tour along the length of Norway when she got stuck in a crevasse and suffered minor injuries. She sent out an emergency signal and a rescue helicopter from Bodø came to her assistance (Helgeland Arbeiderblad, 2/08/2011).

Monitoring: Mass balance measurements performed by University of Århus in 1987-96.
Front position measurements (in 1909-44 (University of Oslo) and since 2006 NVE).
Detailed map surveys in 1965 and 2011.

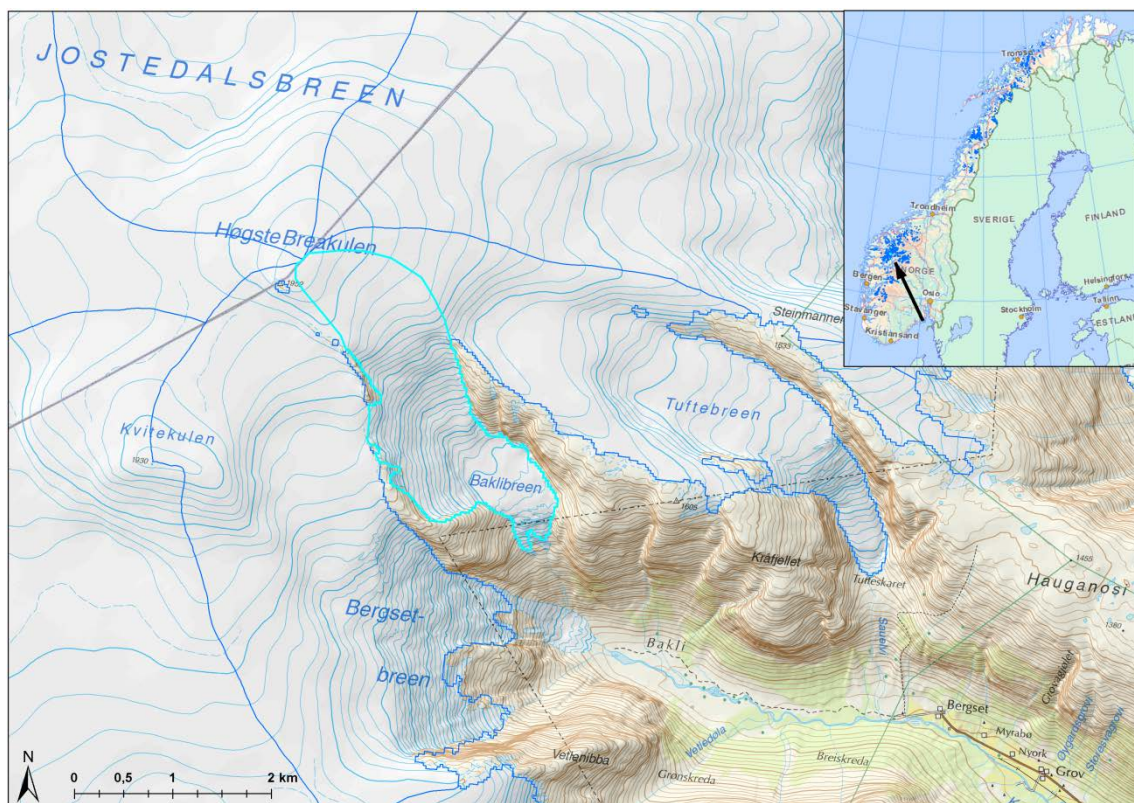
Future risks: Austre Okstindbreen is a crevassed glacier, popular with tourists and mountaineers so similar mountaineering accidents can happen. Several jøkulhlaups occurred from Leirskardsvatnet in the 1970s and 1980s. However, due to continued glacier retreat, there have been no such events for nearly 30 years and this is not considered a present risk. However, the small supraglacial lake shown in the figure above appears relatively new and should be monitored.

References: Helgeland Arbeiderblad: 02.08.2011, 11.08.2006 (Loe, O.M.).
Knudsen, N.T. and W.H. Theakstone. 1988. Drainage of the Austre Okstindbreen Ice-dammed lake, Okstindan, Norway.
NVE glacier database, Norge digitalt, www.norgebilder.no.

Baklibreen

Location:	Luster, Sogn & Fjordane. Latitude: 61.67° N, Longitude: 7.06° E
WGI-ID:	N4A000A4013
NVE-Atlas-ID:	2309
Dimensions:	Area: 3.31 km ² , length: 4.1 km
Altitudinal range:	1035 – 1954 m a.s.l.
Glacier type:	Outlet glacier
Event type:	Ice avalanche, Glacier length change.

Description: A steep glacier outlet from Jostedalsbreen icecap, situated between Bergsetbreen glacier to the west and Tuftebreen to the east. Up until 19th century Baklibreen went so far down into the valley that it was connected to Bergsetbreen. Afterwards it retreated up to the lip of the hanging valley adjacent to Bergsetbreen. Baklibreen drains down to Krundalen valley.



Map: Norge digitalt



Baklibreen photographed from helicopter on 12th October 2006. Photo: Miriam Jackson, NVE

Events (see also p. 186):

27/07/1986 – Ice avalanche. 250,000 – 500,000 m³ ice broke away and slid down into Krundalen, 700 m below. Three people (Dutch family: Gertruida Bakker (39), Bernard (42) and their son Frank (17) van der Kamp) were walking on the path at the bottom of the valley along the river, and were hit by the ice blocks and killed. They were observed by others in the area and appeared not to hear the ice avalanche, probably because they were very close to the river, and didn't realise the danger until it was too late. The body of the son was found the same day, the body of the father in September and that of the mother even later.

Monitoring: NVE photographed the glacier annually between 1986 and 2008. Measurements of surface elevation every year between 1986 and 2005 with Geodimeter (GDM).

Future risks: An ice avalanche is still a possibility, but due to glacier retreat and surface thinning not very likely.

References: Aftenposten 28/07/1986, Dagbladet 28/07/1986, Nytt fra Norge 28/07, 04/08/1986, Rogaland Dagblad 29/07/1986, 05/09/1986, Sandefjords Blad 29/07/1986, Sogn Dagblad 26/08/1986, VG 29/07/1986.

NVE glacier database, Norge digitalt.

Bergsetbreen

Location: Luster, Sogn & Fjordane.
Latitude: 61.66° N, Longitude: 7.04° E

WGI-ID: N4A000A4013

NVE-Atlas-ID: 2318

Dimensions: Area: 11.15 km², length: 5.4 km

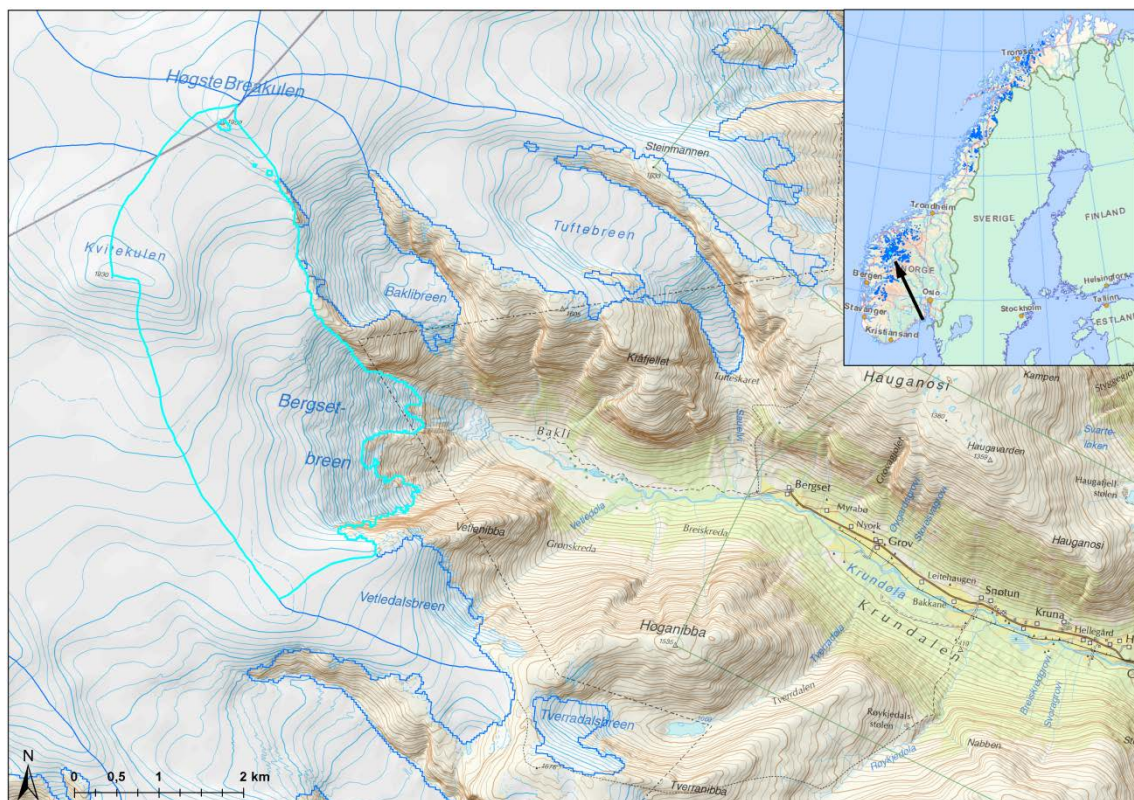
Altitudinal range: 854 – 1957 m a.s.l.

Glacier type: Outlet glacier

Event type: Glacier length change

Description: Steep glacier outlet from Jostedalsbreen icecap on its eastern side, situated between Baklibreen glacier to the north-east, Vetledalsbreen glacier to the south and Tunsbergdalsbreen glacier to the west.

Up until 19th century Baklibreen went so far down into the valley that it was connected to Bergsetbreen. Afterwards Baklibreen retreated up to the rift in the mountainside over Bergsetbreen and the two were no longer connected. Like Vetledalsbreen and Baklibreen, Bergsetbreen also drains to the valley of Krundalen and to Krundøla river.



Map: Norge digitalt



Bergsetbreen on 17th August 2006. Note the stagnating lower part of the glacier that is cut off from the main body of the glacier after rapid retreat the preceding years. Baklibreen is only just visible at the upper right hand side of the photo. Photo: Stefan Winkler (17.08.2006)

Events:

1684 – Glacier length change. High pastures in Bergsetdalen valley belonging to Grov and Bergset farms, were destroyed by the advancing glacier. The farmers were given rights to pasture in Geisdalen and Vanndalen valleys (lokalhistoriewiki.no; Tingbok for Indre Sogn, 1684).

About 1743 – Glacier length change. Bergsetbreen filled most of the upper part of Krundalen valley (Bergsetdalen) and almost connected to Tuftebreen, and was also joined to the advancing Vetledalsbreen glacier. Part of Bergset farms, hayfields and grazing lands including cattle enclosures and summer pastures, were almost completely destroyed by the glaciers (Grove, 1988).

Monitoring: Previously monitored by NVE (1987-2004). Pictures taken at different intervals in the periods 1899-1907 and 1930-1990 and annually from 1993 to 2008.

Future risks: Ice avalanche. Bergsetbreen is easily accessible in a popular tourist area and there is a minor risk of ice avalanches.

References: Grove, J.M. 1988. *The Little Ice Age. Methuen, London and New York*, pp. 64-107.

Tingbok for Indre Sogn, 16 nr 14, 1684, fol. 38a, transcript by Alfred Espe.

NVE glacier database, Norge digitalt, www.lokalhistoriewiki.no.

Blomstølskardsbreen/ Blomsterskardbreen

Location: Etne, Hordaland.
Latitude: 59.99° N, Longitude: 6.36° E

WGI-ID: N4A000AJ009

NVE-Atlas-ID: 3141

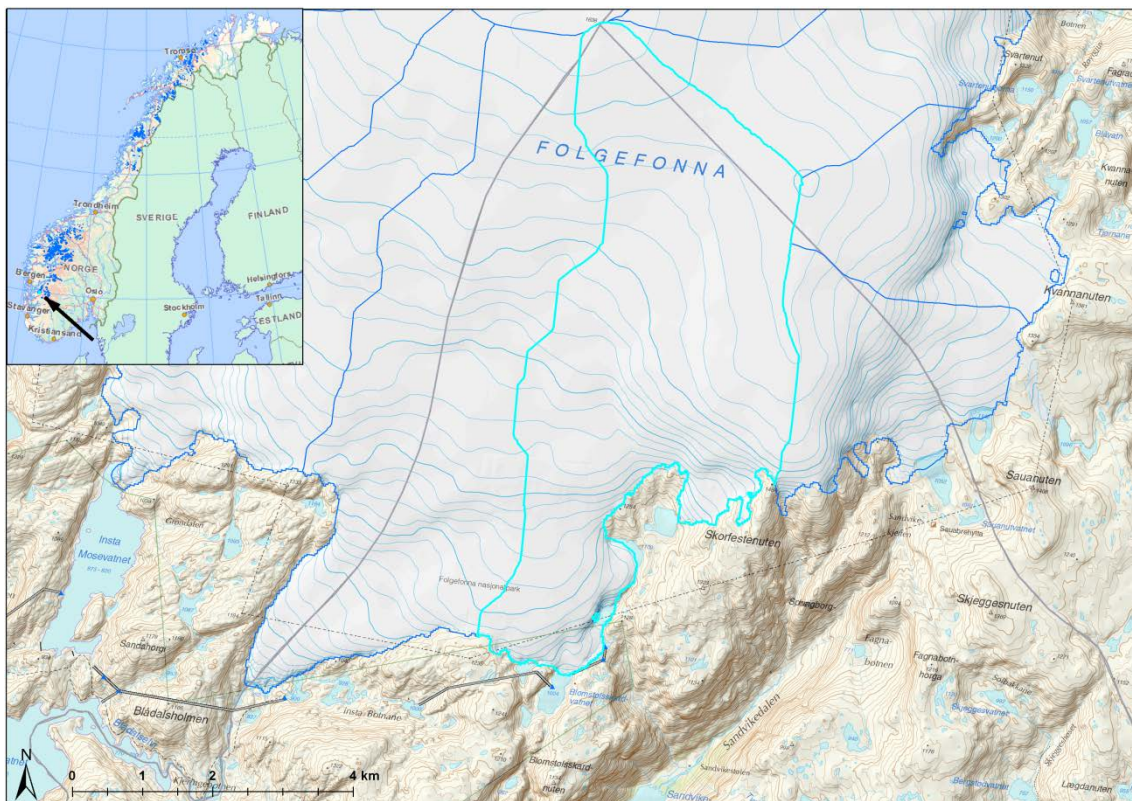
Dimensions: Area: 23.11 km², length: 6.5 km

Altitudinal range: 1033 – 1638 m a.s.l.

Glacier type: Outlet glacier

Event type: Potential jøkulhlaup

Description: Blomstølskardsbreen glacier is one of the southern outlets of Søndre Folgefonna ice cap. The glacier dams the northern part of Lake Blomstølsskardvatnet, giving the lake a southern outflow over a pass. The damming height was about 15 m, corresponding to a reservoir of about 3 million cubic metres in the 1950s. Blomstølsskardvatnet is situated to the south of Blomstølskardsbreen, at the very edge of a precipice on Sandvikdalen.



Map: Norge digitalt

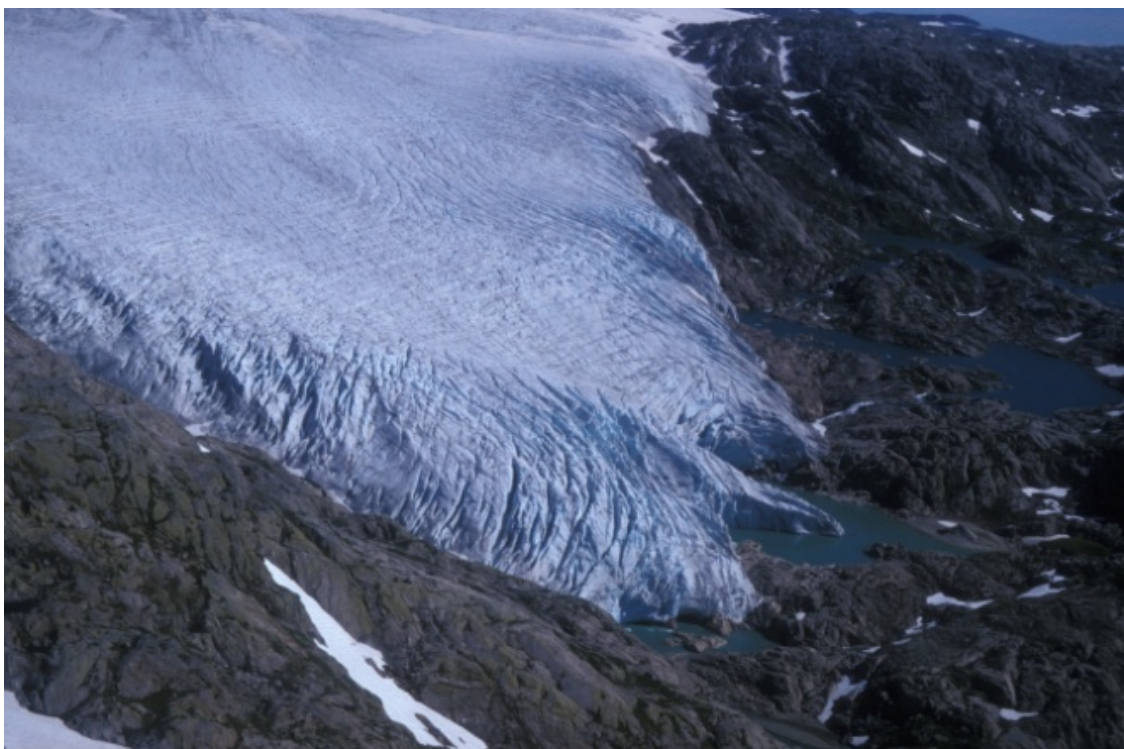


Photo: Hallgeir Elvehøy (NVE, 05/08/1997)

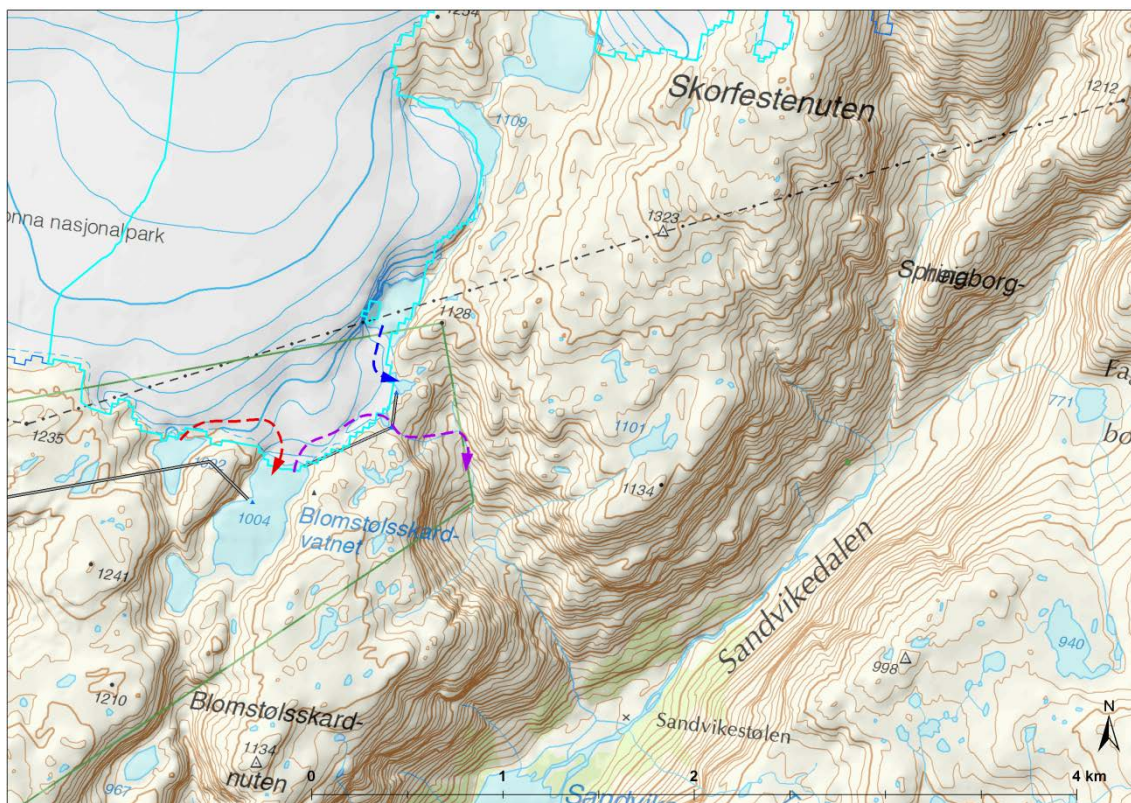
Before the 1960s, it was believed that jøkulhlaups from Lake Blomstølskardvatn were responsible for large floods in river Londalselva (Liestøl, 1956). However later field studies by Arve M. Tvede (1988) combined with inspection of air photographs, showed clearly that the floods actually originated in Sauavatt (see Sauanutbreen, p 125).

In December 1970, the outflow from Blomstølskardvatn was transferred to the river Blådalselva through a 1.8 km long tunnel to increase the power production of the hydropower stations along the river. After lowering the water level in this lake, the outflow to Tverrelva was left dry, and all the water from Blomstølskardsbreen was channeled to Blådalselva. This drainage was stable until the summer of 1994 when most of the water from the glacier again flowed into Tverrelva. Shortly after 1994 a new tunnel was constructed to transfer water from the changed glacier drainage system to Blomstølskardvatn and further to the hydropower stations.

Several lakes exist at the eastern side of the western glacier tongue and at least one of them is dammed by the glacier. This glacier-dammed lake may drain under the ice to a smaller lake, but that drains into a hydropower tunnel and thus is unlikely to pose a danger.

Monitoring: Mass-balance measurements were carried out by NVE in 1970-76 (Tvede and Liestøl, 1977) and from 2007 to the present (e.g. Kjøllmoen, 2011). Ice thickness on parts of Blomstølskardsbreen was measured using radar in 1987 (Kennett and Sætrang, 1987). Front position measurements have been performed since 1994. Detailed map surveys from 1959 and 2007.

Photographs were taken of the glacier in 1904, 1953, 1955, 1959, 1969, 1971, 1976, 1981, 1994, 1997, and a drawing of the area was made in 1938.



Map: Norge digital. Potential pathways for drainage from the glacier-dammed lakes are shown in red, blue and purple.

Future risks: Potential jøkulhlaup, which would probably not be dangerous and may even be beneficial as the water would ultimately drain to a hydropower reservoir

References: Kennett, M. and Sætrang, A. C. 1987. Istykkelsesmålinger på Folgefonna. NVE-Oppdragsrapport 18-87.

Kjøllmoen, B. 2011. Breundersøkelser på Svelgjabreen og Blomstøsskardsbreen. Årsrapport 2011. NVE-Oppdragsrapport B9, 2011.

Liestøl, O. 1956. Glacier Dammed Lakes in Norway. *Norsk geografisk tidsskrift* nr. 3-4. Bind XV, 1955-1956, h. 3-4.

Tvede, A. M. 1989. Floods caused by a glacier-dammed lake at the Folgefonni ice cap, Norway. *Annals of glaciology* 13 (1989), p. 262 – 264.

Tvede, A. M. 1994. Blomsterskardbreen, Folgefonni: En oversikt over breens variasjoner i nyere tid. NVE-rapport 22, 1994.

Tvede, A. M. and Liestøl, O. 1977. Blomsterskardbreen, Folgefonni, mass balance and recent fluctuations. *Norsk Polarinstitutt's Årbok*, 1976, p. 225 – 233.

NVE glacier database, Norge digitalt.

Blåisen

Location: Ulvik, Hordaland.
Latitude: 60.55° N, Longitude: 7.47° E

WGI-ID: N4A000AG001

NVE-Atlas-ID: 2966

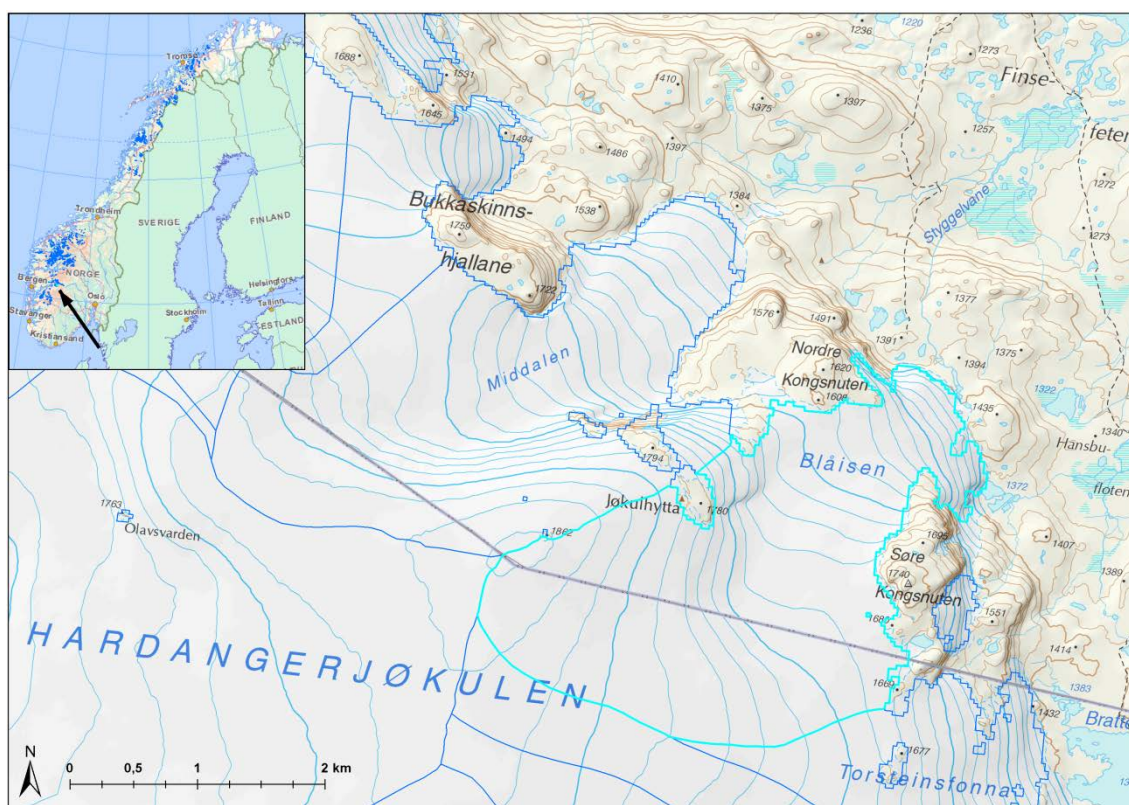
Dimensions: Area: 6.56 km², length: 4.5 km

Altitudinal range: 1372 – 1861 m a.s.l.

Glacier type: Outlet glacier

Event type: Mountaineering accident

Description: North-eastern outlet from Hardangerjøkulen icecap. The glacier is situated between Middalen glacier to the north-west and Torsteinsfonna glacier to the south-east and is surrounded by three mountain peaks – Nordre Kongsnuten (1620 m a.s.l.), Søre Kongsnuten (1740) and a peak (1780) where Jøkulhytta tourist cabin is located.



Map: Norge digitalt



www.norgeibilder.no (22.08.2007)

Events:

17/09/2002 – Mountaineering accident. The accident occurred during a group excursion. A 20-year old female lost her balance and died when she fell 4-5 m into a narrowing crevasse that was 80-90 cm wide at the top. She was not using a rope, and threw her ice axe and other equipment across the crevasse before attempting to jump.

Monitoring: –

Future risks: Blåisen is a heavily crevassed glacier, popular with tourists and mountaineers so similar accidents can happen.

References: Bergensavisen 17/09/2002, Bergens Tidende (bt.no) and others 19/09/2002.

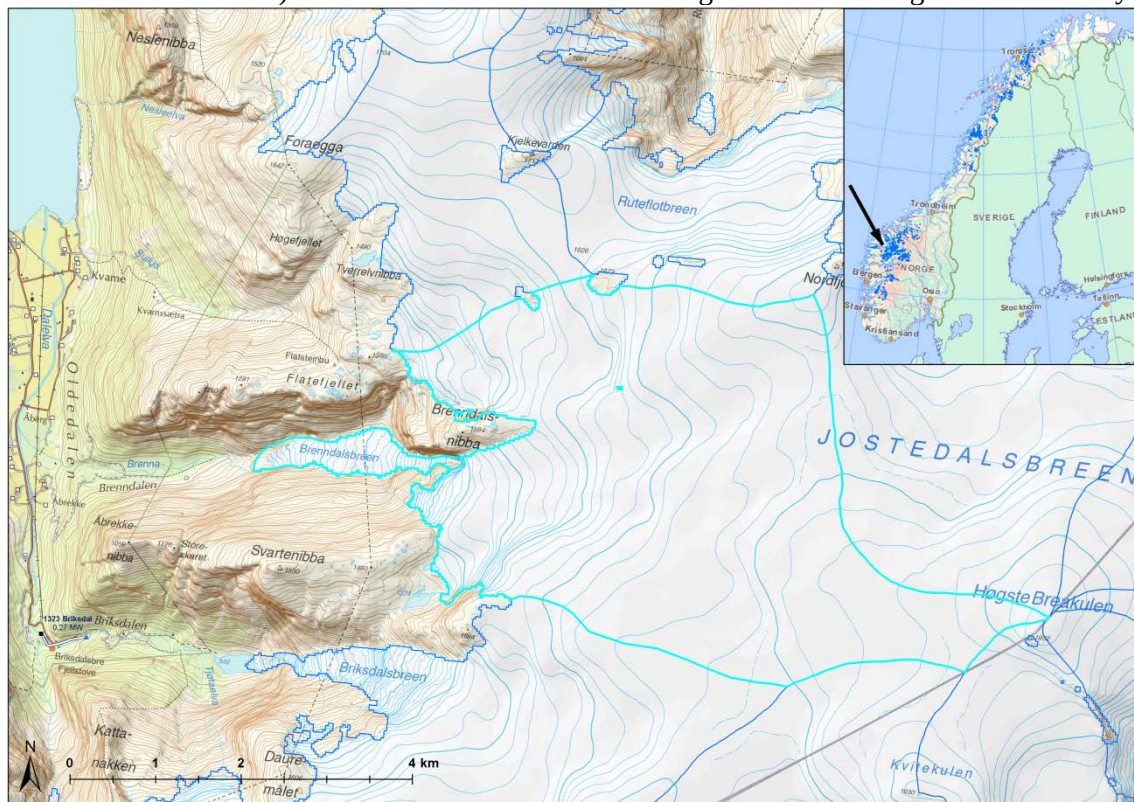
Norges Klatreforbund.

NVE glacier database, Norge digitalt, www.norgeibilder.no.

Brenndalsbreen/ Åbrekkebreen

Location:	Stryn, Sogn & Fjordane. Latitude: 61.69° N, Longitude: 6.94° E
WGI-ID:	N4A000BS009
NVE-Atlas-ID:	2305 and 2301
Dimensions:	Area: 20.84 km ² , length: 9.6 km
Altitudinal range:	410 – 1952 m a.s.l.
Glacier type:	Outlet glacier
Event type:	Glacier length changes, Ice avalanche, Jøkulhlaup

Description: One of the western outlets from Jostedalsglaciens icecap, which lies parallel to and north of Briksdalsbreen glacier. Brenndalsbreen is now in two separate parts. The lowermost part of the glacier (area: 0.72 km², length: 2.4 km) is situated in the upper part of Brenndalen valley and is separated from the main glacier by a steep cliff (about 150 m of elevation over 50 m of distance). Brenndalsbreen underwent a large advance during the 18th century.



Map: Norge digitalt



Brenndalsbreen photographed on 23rd June 2005. Photo: Stefan Winkler

Events:

1720 – Jøkulhlaup. Arable land and pastures belonging to Åbrekke farm were completely destroyed and carried away by a burst of water from the advancing glacier, forming a substantial trench across the farm land (Grove, 1988).

1734 – Jøkulhlaup. Water and ice from the glacier flooded farmland at Tungøyen. The glacier hung over the farm and destroyed most of the remaining arable land (Grove, 1988).

12/12/1743 – Glacier length change/Ice avalanche. Brenndalsbreen advanced to the main valley (Oldedalen) 4.5 kilometres in 50 years (1680-1740). Avalanche consisted of ice, rock, gravel, water from the glacier terminus. Tungøyane farm in Oldedalen was destroyed and only two people survived. The number of dead is not known, but at least three and probably five. Horses, cattle, dogs and sheep were also killed (Eide, 1955; Hagen, 1988; Nesje, 1994).

Monitoring: Photographs taken in 1869, 1900 and almost annually from 1997 to present. Front position measurements in 1900-62 and from 1996 to present.

Future risks: Probably no risk due to glacier retreat.

References: Eide, T.O., 1955. Breden og bygda. *Noreg Tidsskrift for folkelivsgransking*, Vol. 5, p. 1-40.

Grove, J.M. 1988. The Little Ice Age. *Methuen, London and New York*, pp. 64-107.

Hagen, K. 1988. Rasfare ved Stor-Glomfjordutbyggingen. *NVE Rapport nr. 2-88*, 38p.

Nesje, A. 1994. Eit tragisk 250-års minne – Raset frå Brenndalsbreen I Oldedalen den 12. Desember 1743. *Naturen* nr. 2 1994, pp. 67-70.

NVE glacier database, Norge digitalt.

Briksdalsbreen

Location: Stryn, Sogn & Fjordane.
Latitude: 61.66° N, Longitude: 6.92° E

WGI-ID: N4A000BS010

NVE-Atlas-ID: 2316

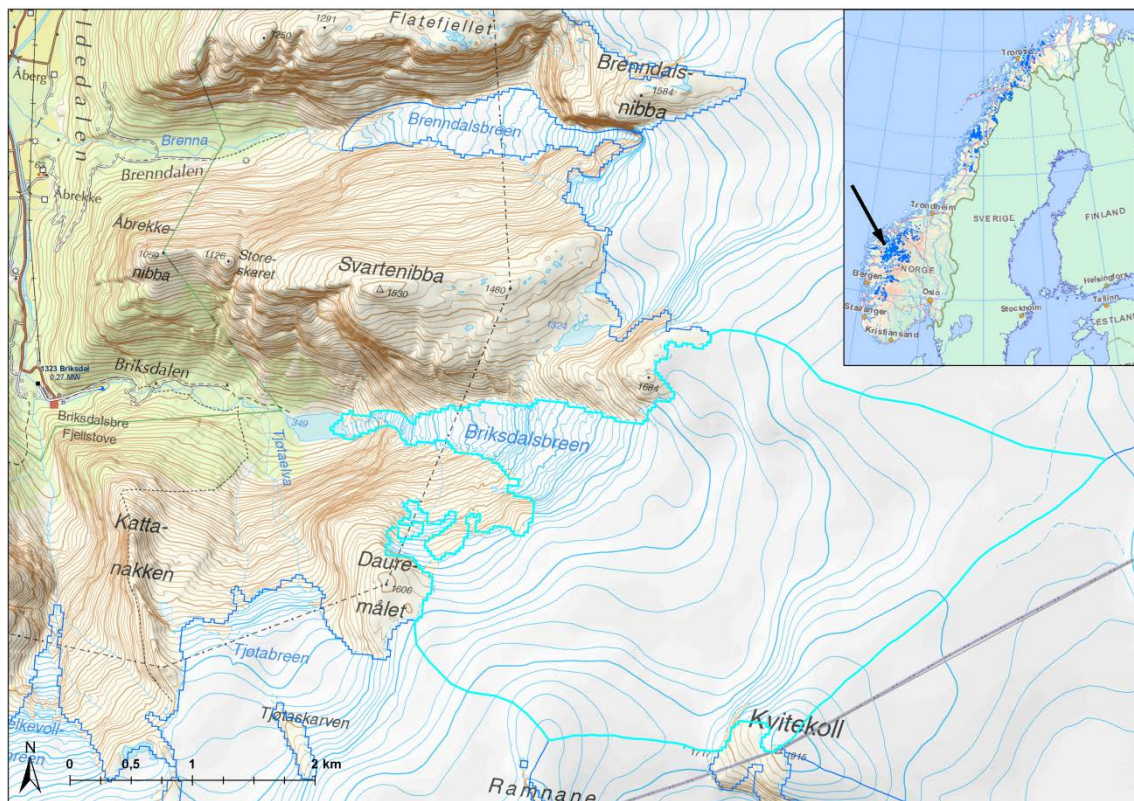
Dimensions: Area: 11.73 km², length: 5.2 km

Altitudinal range: 349 – 1917 m a.s.l.

Glacier type: Outlet glacier

Event type: Mountaineering accident

Description: Briksdalsbreen is an outlet from the Jostedalsglaciær icecap. It is one of the most visited glaciers in Norway. Previously there were guided tours on the lowest part of the glacier during the summer, and it was a popular place for glacier courses. During the past few years it has retreated several hundred metres, and the tongue is now quite steep, making it difficult for tours onto the glacier.



Map: Norge digitalt



Briksdalsbreen photographed on 30th October 2005 (left) and in 2012 (right) by Kurt Erik and Atle Nesje, respectively

Events:

06/05/2000 – Mountaineering accident. Male guide (20) slipped because of loose crampon after finishing climbing with tourists. Fell 10-15 metres down, and suffered broken leg. He was carried down on a stretcher (Norges Klatreforbund).

28/10/2000 – Mountaineering accident. The fifth person in a 6-person rope team slipped and fell on steep ice. The third and fourth were dragged along and the third landed head-first on an ice-shelf 1.5 metres below. Result: one injured, concussion, facial cuts, four broken facial bones, crushed helmet, which probably saved his life. Cause of slipping unknown, but soft shoes may have been a contributing factor. Rescue operation executed by the guide (Norges Klatreforbund).

20/08/2001 – Mountaineering accident. The last person in a 5-person rope team fell while walking beside a crevasse, and dragged two other people into it. These two ended up hanging in the tight rope, and one was injured. They used helmets and that probably helped reduce personal injury (Norges Klatreforbund).

Monitoring: Front position measurements from 1900, observations and photographs (from 1869) almost every year.

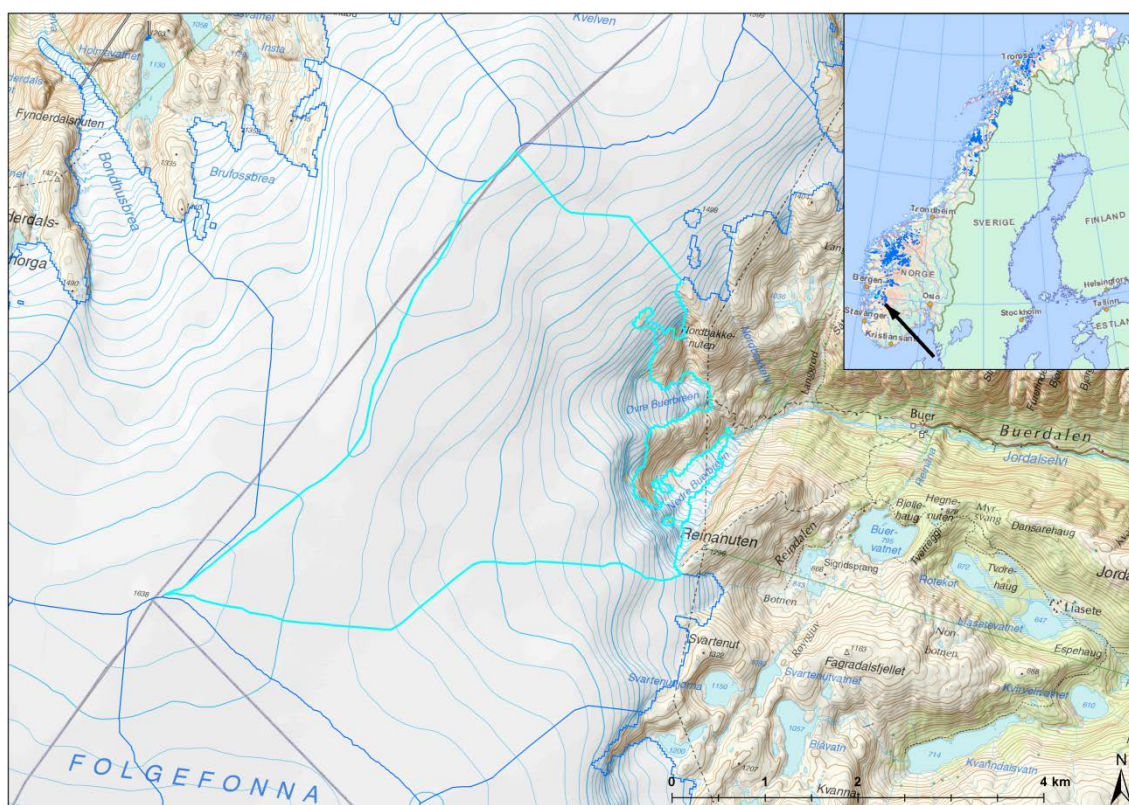
Future risks: If the glacier continues to retreat then ice avalanches could become a danger.

References: Norges Klatreforbund.
NVE glacier database, Norge digitalt.

Buerbreen

Location:	Odda, Hordaland. Latitude: 60.04° N, Longitude: 6.39° E
WGI-ID:	N4A000AK005
NVE-Atlas-ID:	3131
Dimensions:	Area: 14.44 km ² , length: 7 km
Altitudinal range:	700 – 1645 m a.s.l.
Glacier type:	Outlet glacier
Event type:	Glacier length change, Mountaineering accident

Description: Buerbreen is one of the eastern outlets from Søndre Folgefonna icecap. It is situated between Bondhusbrea and Brufossbrea glaciers to the west and Ruklebreen glacier to the north-east. Buerbreen has three tongues: Nedre Buerbreen, Øvre Buerbreen and an unnamed tongue west of Nordbakkenuten mountain. All the tongues are highly crevassed. They all drain to Jordalselvi river in the valley of Buerdalen. There is a footpath leading to Øvre Buerbreen.



Map: Norge digitalt



Buerbreen photographed from helicopter on 5th October 1997. Photo: Hallgeir Elvehøy, NVE

Events:

1832 – 1878 – Glacier length change. Buerbreen advanced significantly, 1700 m, in this period and covered a considerable expanse of pasture. The glacier advanced more than 80 m in 1870, and 4 m in just one week in 1871. The front of Buerbreen continued to advance after 1878 (Grove, 1988).

08/08/1957 – Mountaineering accident. An English scoutmaster froze to death after falling into a 5 m deep crevasse on Buerbreen. The crevasse was not covered by snow and thus was very visible. The scoutmaster did not take any safety precautions, came too close to the edge and slipped. He was dressed in summer shorts.

There were five boy scouts in the troop. Three of them ran to get help while the others stood watch. However, they subsequently left as they were wearing only summer clothing and were taken to a hospital in the town of Odda (Aftenposten 09/08/1957).

Monitoring: Buervatn lake is regularly observed by NVE.

Front position measurements at Buerbreen were performed in 1900-80 and in 1995. Detailed map survey in 1959 and in 2007.

Future risks: Jøkulhlaup and ice avalanche.

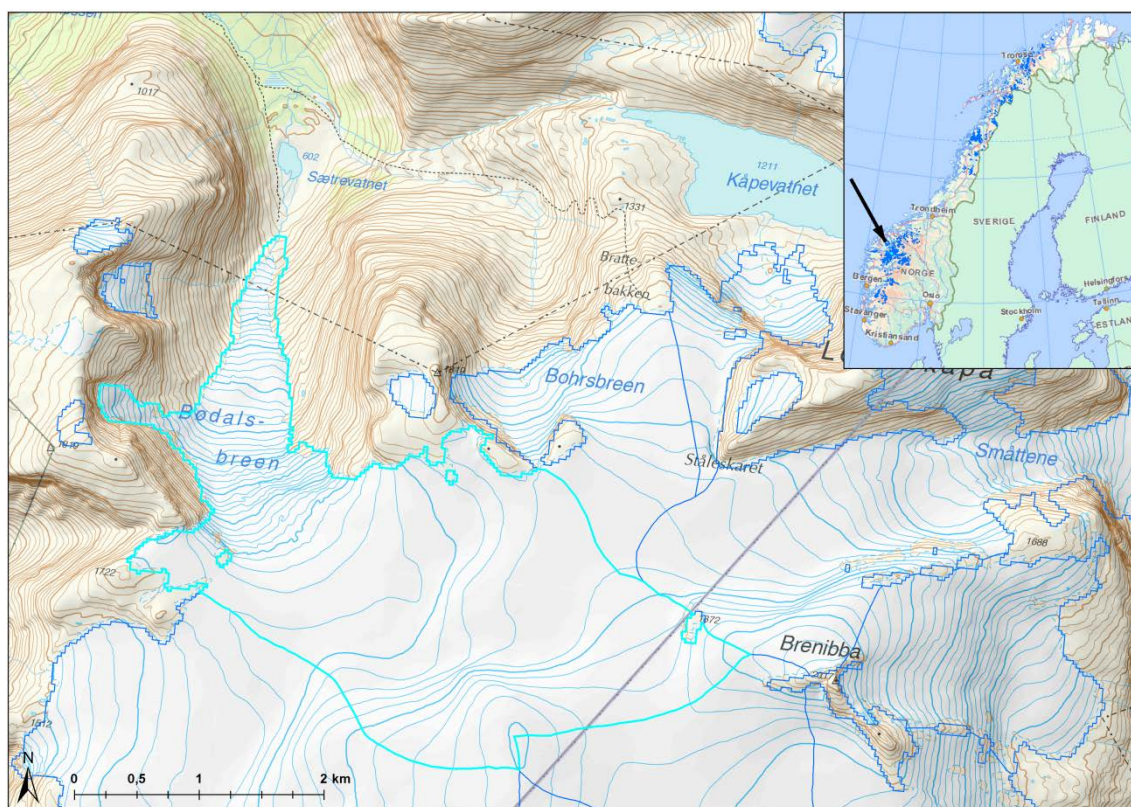
References: Aftenposten 09/08/1957.

Grove, J.M. 1988. The Little Ice Age. *Methuen, London and New York*, pp. 64-107.

NVE glacier database, Norge digitalt.

Bødalsbreen

Location:	Stryn, Sogn & Fjordane. Latitude: 61.76° N, Longitude: 7.14° E
WGI-ID:	N4A000BT019
NVE-Atlas-ID:	2273
Dimensions:	Area: 8.41 km ² , length: 6.5 km
Altitudinal range:	654 – 1923 m a.s.l.
Glacier type:	Outlet glacier
Event type:	Mountaineering accident, Glacier length change
Description:	Northern outlet glacier from Jostedalsglaciær icecap. It is situated between Krunebreen glacier to the south-west and Bohrsbreen glacier to the north-east. Bødalsbreen drains to a small lake, Sætrevatnet, and thence to Bødalselva river and eventually to Lovatnet lake.



Map: Norge digitalt



Bødalsbreen photographed from helicopter on 16th August 2012. Photo: Hallgeir Elvehøy, NVE

Events:

1693 – Glacier length change (advance). The advance of the glacier was associated with increased damage from landslides, rockfalls, avalanches and flooding. Boedahl farm suffered substantial damage (Grove, 1988).

28/07/1986 – Mountaineering accident. Five roped men fell and slid off the glacier. One person killed, two seriously injured and two slightly injured (Dagbladet 29/07/1986, Hamar Dagblad 29/07/1986, Stavanger Aftenblad 30/07/1986, Ringsaker Blad 05/08/1986).

Monitoring: Annual photography and observations since 1992. Photos also in 1869, 1871, 1906 and 1907.

Front position measurements 1900-53 and from 1996.

Future risks: The usual risks apply for glacier walking and ice climbing.

References: Dagbladet 29/07/1986, Hamar Dagblad 29/07/1986, Ringsaker Blad 05/08/1986, Stavanger Aftenblad 30/07/1986.

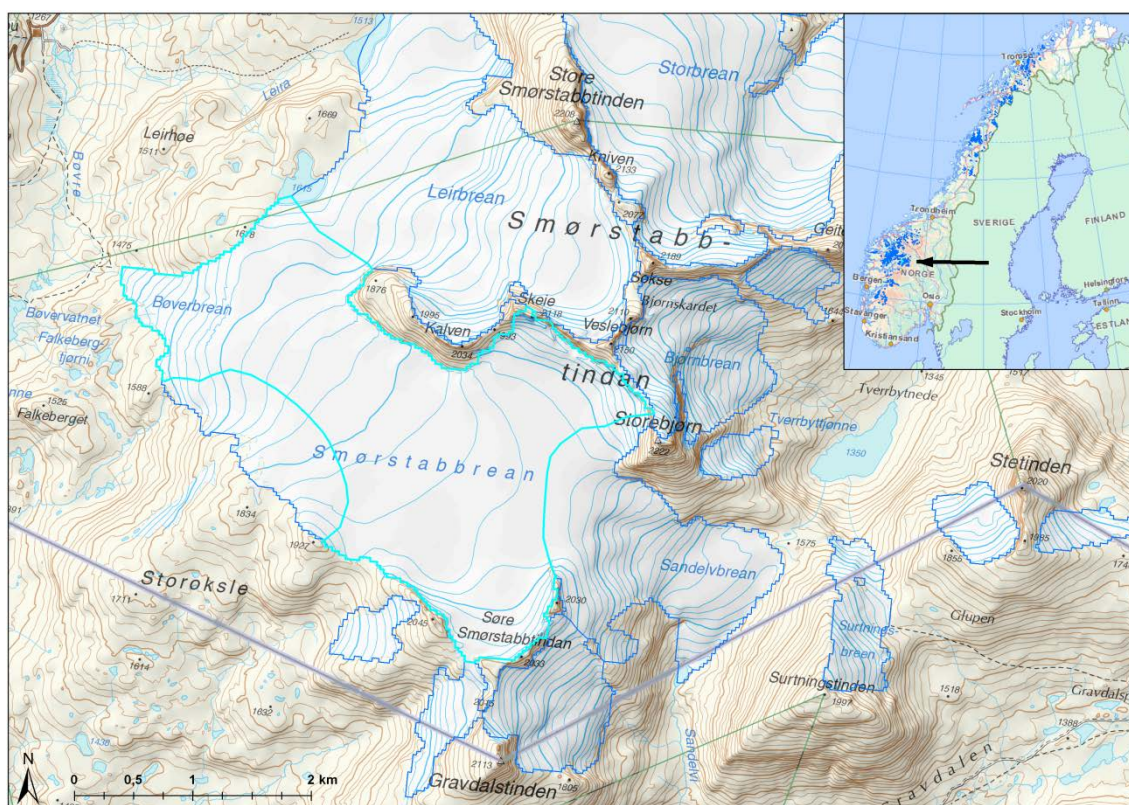
Grove, J.M. 1988. The Little Ice Age. *Methuen, London and New York*, pp. 64-107.

NVE glacier database, Norge digitalt.

Bøverbrean

Location:	Lom, Oppland. Latitude: 61.55° N, Longitude: 8.09° E
WGI-ID:	N4A000AD048
NVE-Atlas-ID:	2643
Dimensions:	Area: 6.75 km ² , length: 5 km
Altitudinal range:	1432 – 2143 m a.s.l.
Glacier type:	Outlet glacier
Event type:	Mountaineering accident

Description: Outlet glacier from Smørstabbrean, central Jotunheimen. It is situated on the western side of Smørstabbtinden glacial horn, between Leirhøe peak (1511 m a.s.l.) to the north-west, Falkeberget mountain (1525) to the west, Søre Smørstabbtinden (2033, 2045) to the south and Kalven (2034), Skeie (2118), Veslebjørn (2150) and Storebjørn (2222) peaks to the north-east. Bøverbrean is popular with tourists due to easy access from the main road. The glacier drains to Bøvre river.



Map: Norge digitalt



Bøverbreen photographed from Sognefjellet on 05th August 2004. Photo: Liss Marie Andreassen, NVE

Events:

September 1986 – Mountaineering accident. Two people in a group of 60 Swedish sixth-formers fell into a 12-metre deep crevasse while on a glacier tour. They were quickly rescued from the crevasse (Dagningen 13/09/1986).

03/07/1998 – Mountaineering accident (there is some uncertainty about the exact location). A woman got her ice axe in her thigh during practice in difficult, steep ice. No major injury. She was experienced, but used to a shorter ice axe (Norges Klatreforbund).

07/08/1998 – Mountaineering accident. Male 44, part of a glacier course, fell and slid on hard snow. Moderately experienced. One person injured – broken rib (Norges Klatreforbund).

19/07/2003 – Mountaineering accident. One of four people on a glacier tour fell into a crevasse. One of his crampons stuck in an ice-screw in his harness when he tried to jump over the crevasse. He landed inside the crevasse 1.5 metres away from where he jumped, and hit the edge on the opposite side and broke his left leg. He was rescued by the rest of the team (Norges Klatreforbund).

04/07/2006 – Mountaineering accident. 35 year old female course participant, inexperienced with crampons, was practising walking on ice under simple conditions. She stumbled when she encountered a dip in the ice, and her right achilles tendon was injured (Norges Klatreforbund).

10/05/2008 – Mountaineering accident. Male 52, skier, fell into crevasse. Hypothermia.

19/07/2012 – Mountaineering accident. A rope team of nine members was crossing a snow bridge over a 50-60 cm wide crevasse with blue ice on the other side. The last person fell about 2 m into the crevasse. The team guide came back, secured the rope team and rescued the woman. She suffered a minor knee injury (Norges Klatreforbund).

Monitoring: Photographs (1998, 2003-06, 2009-11) and front position measurements (1903-12, 1936-63 and from 1997).

Future risks: Usual risks for glacier walking and mountaineering.

References: Dagningen13/09/1986.
Norges Klatreforbund.
NVE glacier database, Norge digitalt.

Dimdalsbreen

Location: Meløy, Nordland.
Latitude: 66.7° N, Longitude: 13.88° E

WGI-ID: N4A000C4006

NVE-Atlas-ID: 1090

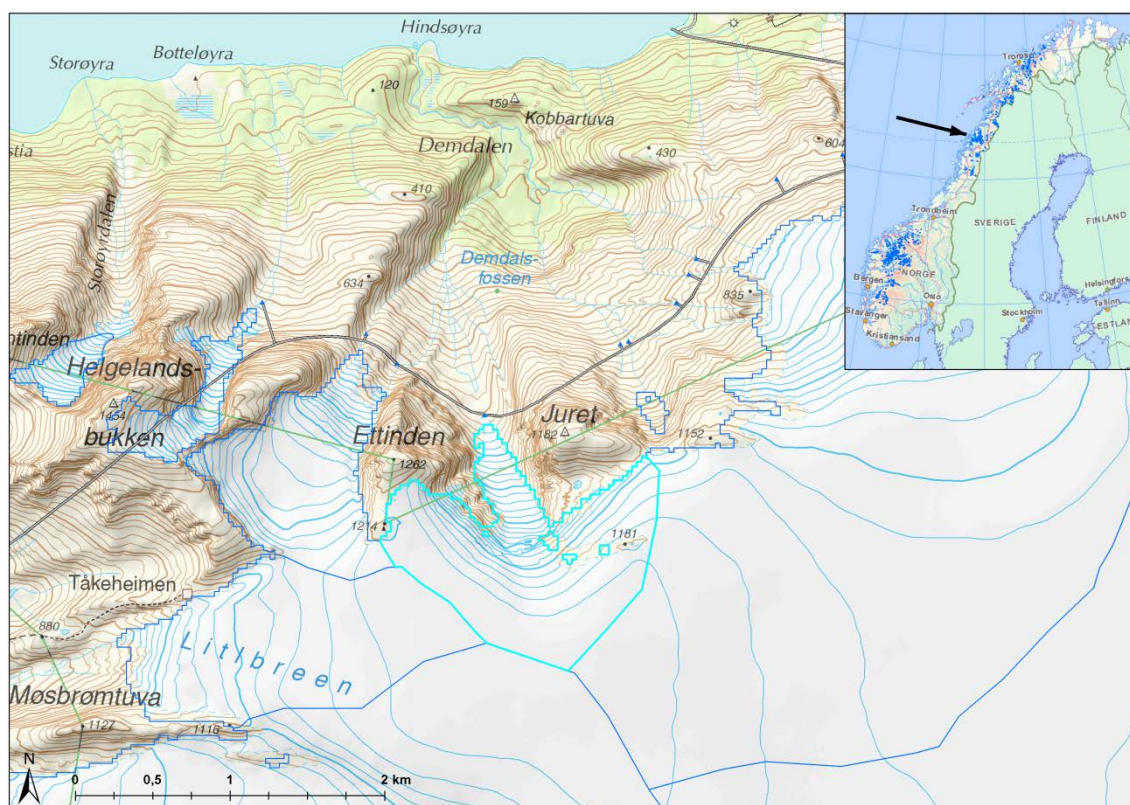
Dimensions: Area: 1.52 km², length: 2 km

Altitudinal range: 629 – 1203 m a.s.l.

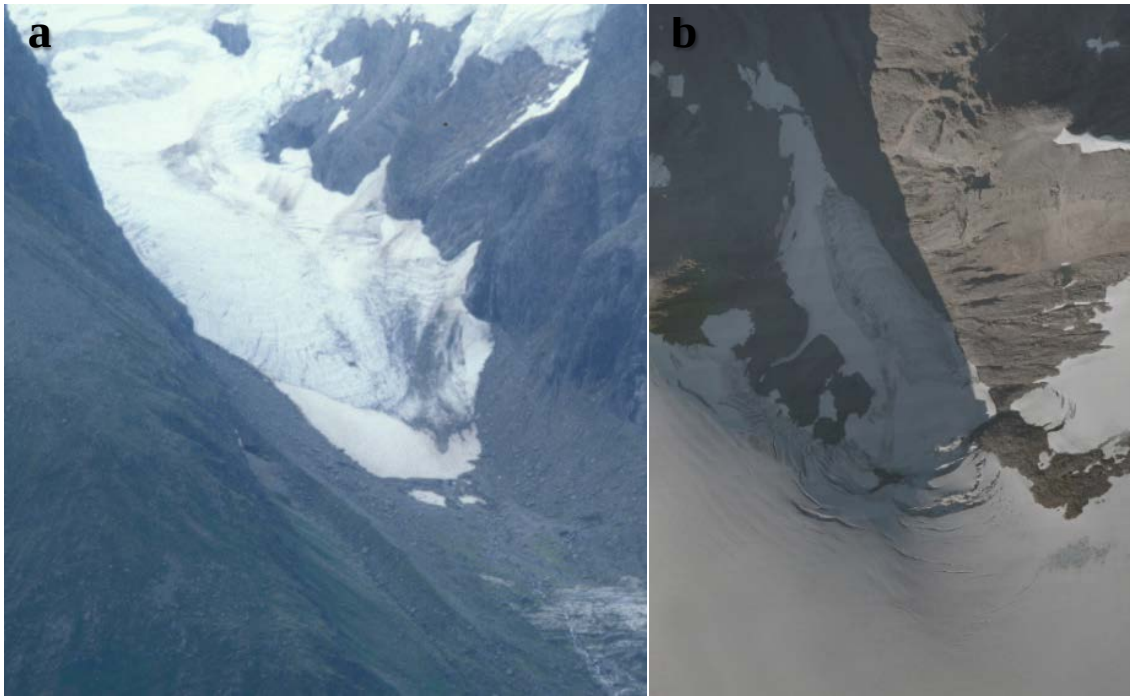
Glacier type: Outlet glacier

Event type: Glacier length change

Description: Dimdalsbreen is an informal name for a small western outlet glacier from Vestre Svartisen icecap, which lies between Ettinden and Juret mountain peaks on the southern side of Holandsfjord. The glacier is about 2 km long with a steep ice-fall from the plateau down to the tongue which is about 1 km long.



Map: Norge digitalt



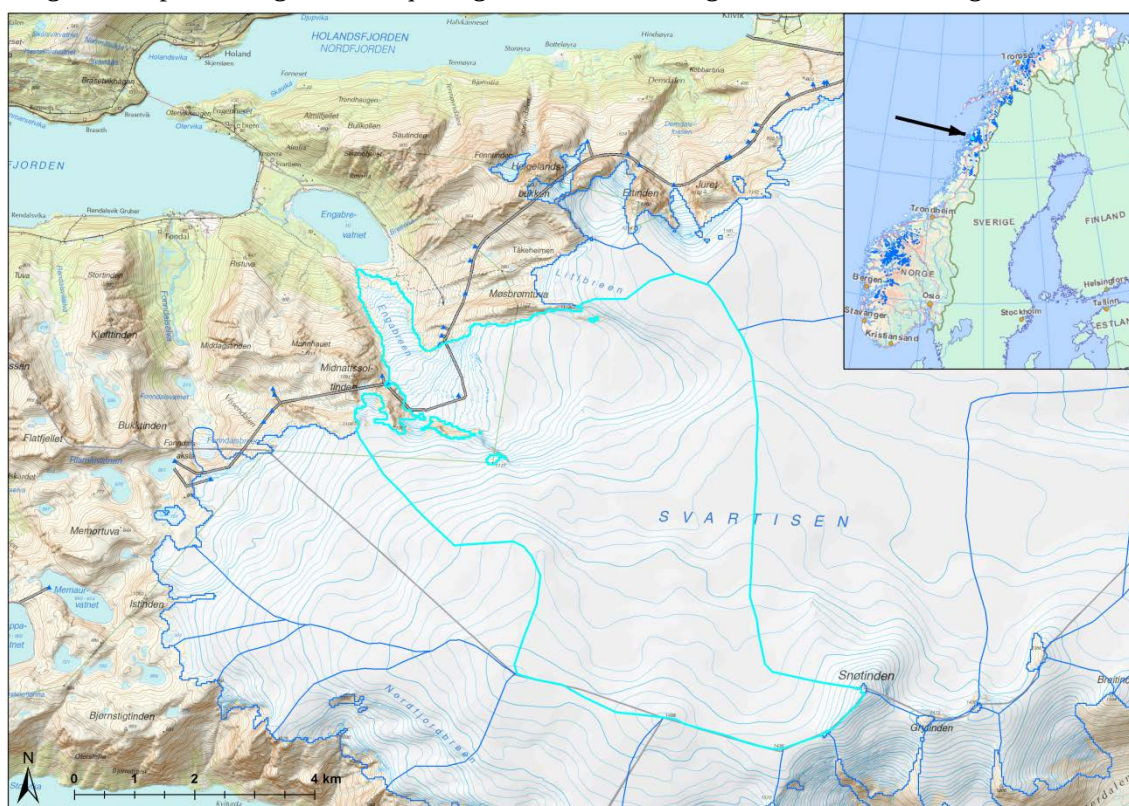
a – The front of Dimdalsbreen photographed in October 1998 by Hallgeir Elvehøy, NVE

b – Dimdalsbreen from www.norgeibilder.no (24.08.2008)

- Events:** From 1968 to 1997 the glacier front advanced 60.9 m (Kohler, 1997).
- Monitoring:** Dimdalsbreen was investigated and its development modelled numerically by Jack Kohler (NVE) in 1997. Pictures taken in 1996 and 1998 by NVE.
- Future risks:** One of the intakes for Statkraft's Svartisen power plant, which is situated just in front of Dimdalsbreen, may become covered by ice if the glacier advances.
- References:** Kohler, J., 1997. Forandringer på en bretunge i Dimdalen, Svartisen: observasjoner og modellering. *NVE Rapport nr 20*, 1997.
- NVE glacier database, Norge digitalt, www.norgeibilder.no.

Engabreen

Location:	Meløy, Nordland. Latitude: 66.66° N, Longitude: 13.85° E
WGI-ID:	N4A000C4011
NVE-Atlas-ID:	1094
Dimensions:	Area: 36.02 km ² , length: 12.2 km
Altitudinal range:	14 – 1581 m a.s.l.
Glacier type:	Outlet glacier
Event type:	Glacier length change
Description:	North-western outlet from Vestre Svartisen icecap. It is situated between Fonndalsbreen glacier to the west and Storglombreen glacier to the east. The tongue of Engabreen is highly crevassed. Engabreen drains to Engabrevatnet lake and thence to Holandsfjord. There is a hydropower water transfer tunnel under the glacier with several intakes both under and adjacent to Engabreen.
	Svartisen Subglacial Laboratory is situated under 200 m of ice under Engabreen glacier. The laboratory provides a unique opportunity for direct access to the bed of a temperate glacier for the purposes of measuring sub-glacial parameters and performing experiments on the ice.
	Engabreen is popular among tourists due to easy access and picturesque surroundings. There are guided trips on the glacier, frequent glacier courses and general mountaineering.



Map: Norge digitalt



Photo of Engabreen tongue taken on 16th April 2002. Photo: Miriam Jackson, NVE

Events:

1723 – Glacier length changes. Glacier advance; Storsteinøyra farm was destroyed by the glacier (Grove, 1988).

Monitoring: Mass balance measurements by NVE from 1970.
Front position measurements from 1903.
Detailed map surveys in 1968, 1985, 2001-03, 2008.
Svartisen subglacial laboratory; basal pressure, seismic array.

Future risks: There is no present risk.

References: Grove, J.M. 1988. *The Little Ice Age. Methuen, London and New York*, pp. 64-107.

Hagen, K. 1988. Rasfare ved Stor-Glomfjordutbyggingen. *NVE Rapport nr. 2*, 38s

Rekstad, J., 1893. Beretning om en undersøkelse av Svartisen, foretagen somrene 1890 og 1891. *Archiv for Mathematik og Naturvidenskaberne*, 21, pp. 229-270.

NVE glacier database, Norge digitalt.

Finnebreen

Location: Rauma, Møre & Romsdal.
Latitude: 62.45° N, Longitude: 7.62° E

WGI-ID: N4A000CG032

NVE-Atlas-ID: 1765

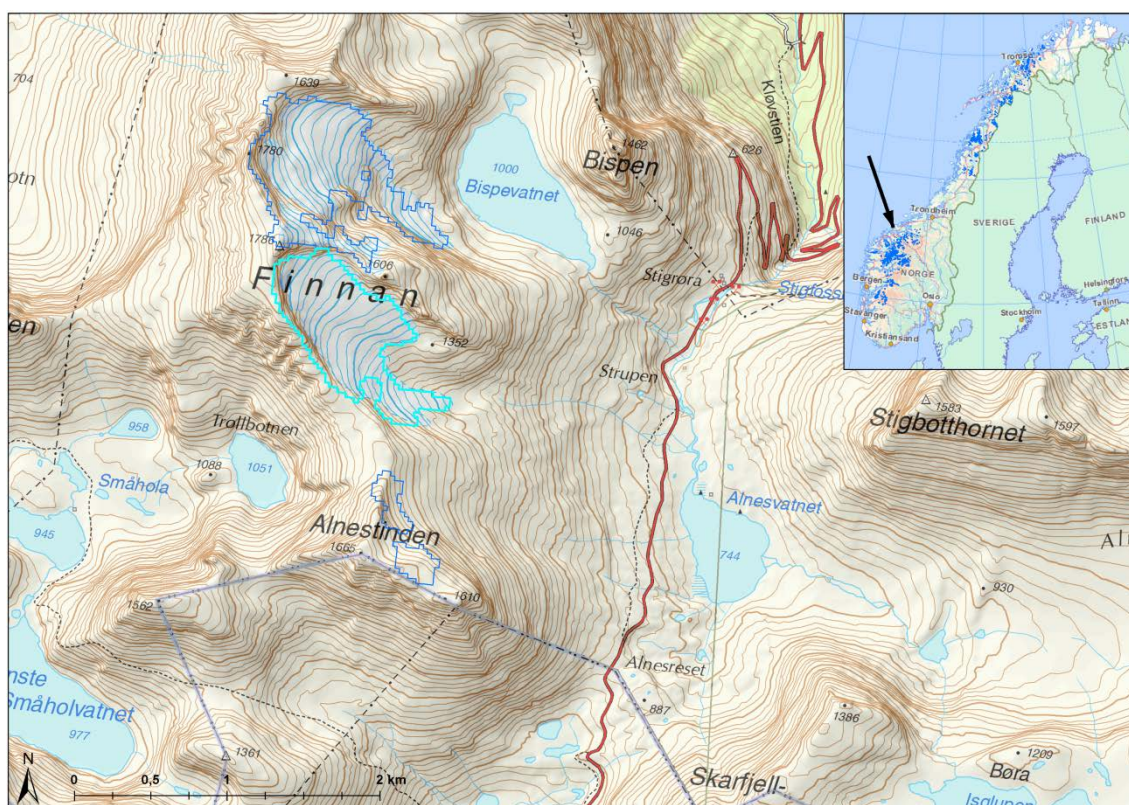
Dimensions: Area: 0.58 km², length: 1.5 km

Altitudinal range: 1199 – 1716 m a.s.l.

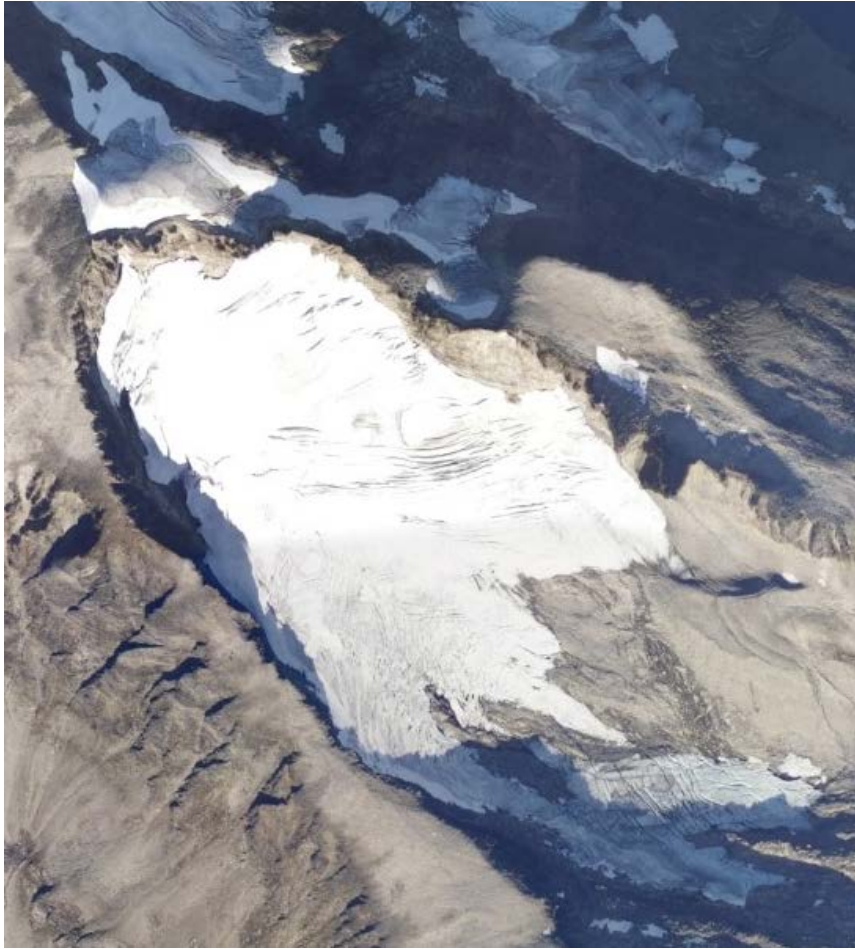
Glacier type: Cirque glacier

Event type: Mountaineering accident

Description: Small cirque glacier, situated to the south-west of Bispevatnet lake, between Smørbottstinden glacial horn (1520 m a.s.l.) to the west, Bispen mountain peak (1462) to the north-east and Alnestinden mountain summit (1665) to the south. Finnebreen drains to Istra river in Isterdalen valley. The glacier is close to Trollstigen, a popular tourist road.



Map: Norge digitalt



www.norgebilder.no (22.09.2006)

Events:

07/07/1977 – Mountaineering accident. Two Italian tourists fell into two separate crevasses on the southern part of the glacier and died. Due to bad weather, rescue operations were cancelled. The two bodies were found in September 1996, 19 years later (Romsdals Budstikke 18/09/1996).

Monitoring: Length change observations 1950 – 1975.

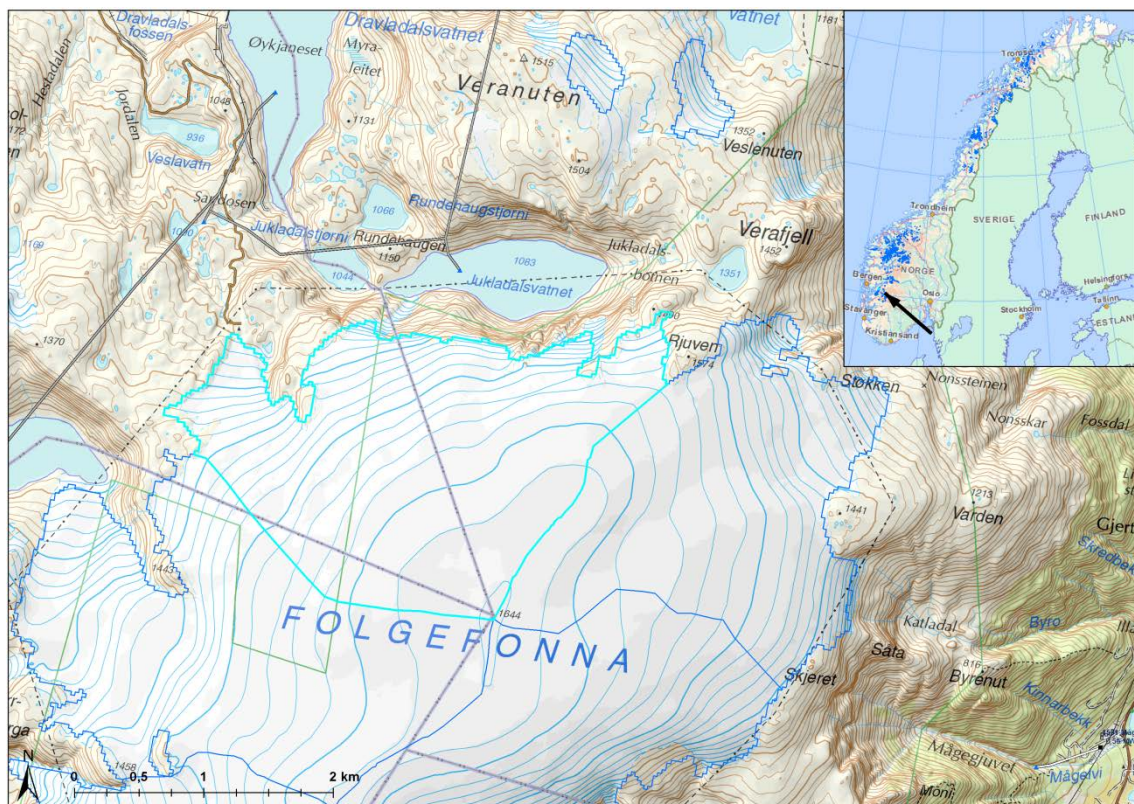
Future risks: The usual risks apply for glacier walking and ice climbing.

References: Romsdals Budstikke 18/09/1996.
NVE glacier database, Norge digitalt, www.norgebilder.no.

Folgefonna, Nordre (NV)

Location:	Jondal, Hordaland. Latitude: 60.22° N, Longitude: 6.47° E
WGI-ID:	N4A000AJ013
NVE-Atlas-ID:	3113
Dimensions:	Area: 5.44 km ² , length: 3.3 km
Altitudinal range:	1189 – 1644 m a.s.l.
Glacier type:	Outlet glacier
Event type:	Jøkulhlaup, Mountaineering accident

Description: North-western outlet from the ice cap Nordre Folgefonna, between Hardangerfjorden to the west and Sørfjorden to the east. It drains to lakes Jukladalsvatnet (1083 m a.s.l.) and Jukladalstjørni (1044 m a.s.l.). In the north-western part of the glacier there is an unnamed glacier-dammed lake at an elevation of 1199 m a.s.l. (Photos a, b, c).



Map: Norge digitalt



a – Western tongue of Nordre Folgefonna (NV) photographed from helicopter on 10th October 2006. Photo Hallgeir Elvehøy, NVE;

b – Western tongue of Nordre Folgefonna (NV). Red dashed line shows probable drainage path in case of a jökulhlaup. Photo: www.norgebilder.no (18/08/2006).;

c – Drained glacier-dammed lake on 15th September 2009. Photo: FONNA Glacier Ski Resort.

Events:

15/10/2000 – Mountaineering accident. A 28 year-old man fell into a bergschrund at Folgefonna ski centre, and suffered moderate injuries (Bergens Tidende, 2000 - archive).

12/09/2009 – Jökulhlaup. 12,000 m³ of water disappeared under the glacier ice in just a few minutes (Bergens Tidende, 2009). No damage was reported by Folgefonna Summer Ski Centre situated just 250 m away from this unnamed glacier-dammed lake.

Monitoring: Pictures taken by NVE in 2006 and 2009.

Future risks: Mountaineering and skiing accidents. Jøkulhlaup. Several thousand cubic metres of water may be released and damage the ski-centre buildings situated just 250 m from the lake. The ski-lift may be affected if there is collapse of the drainage tunnel after a jøkulhlaup.

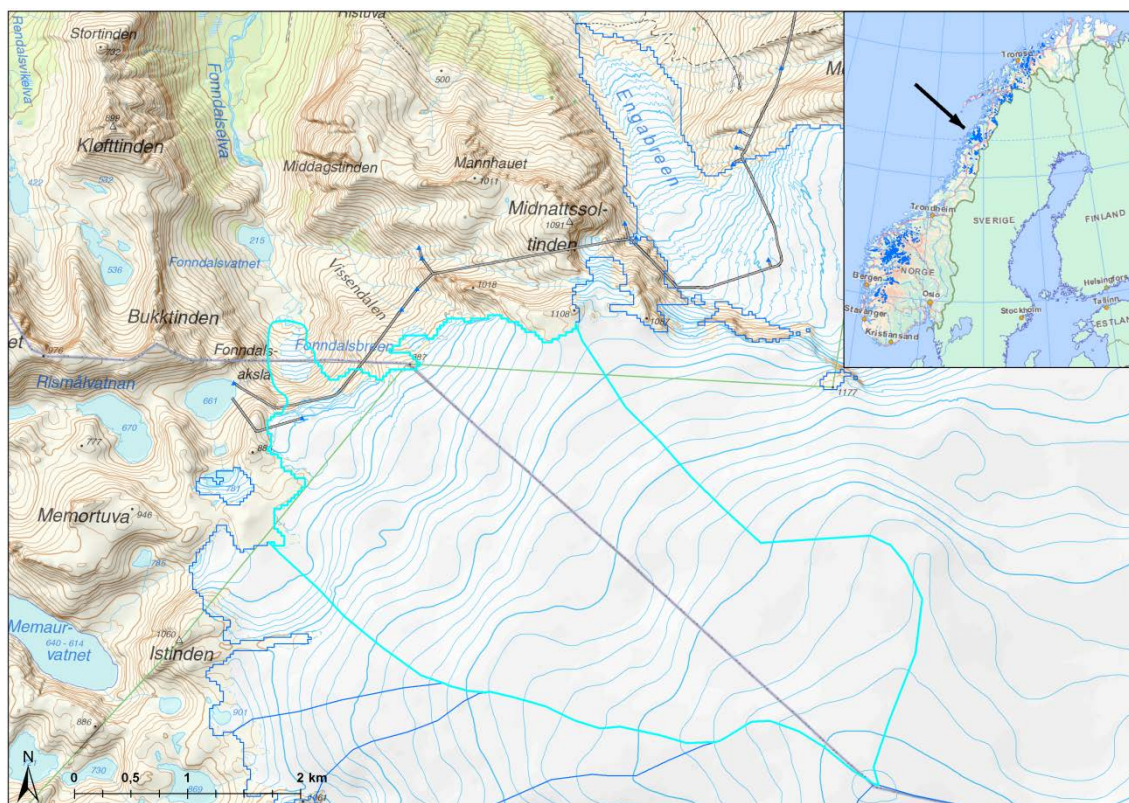
References: Bergens Tidende (22.09.2009): <http://www.bt.no/nyheter/lokalt/Sjoen-forsvann-pa-ei-natt-1933459.html>

Bergens Tidende (2000, archive): [bt.no/lokalt/article25626](http://www.bt.no/lokalt/article25626).

NVE glacier database, Norge digitalt, www.norgeibilder.no.

Fonndalsbreen

Location:	Rødøy / Meløy, Nordland. Latitude: 66.65° N, Longitude: 13.76° E
WGI-ID:	N4A000C4012
NVE-Atlas-ID:	1097
Dimensions:	Area: 13.87 km ² , length: 7.2 km
Altitudinal range:	302 – 1421 m a.s.l.
Glacier type:	Outlet glacier
Event type:	Ice avalanche, Glacier length change
Description:	Fonndalsbreen is an outlet glacier of Western Svartisen ice cap immediately south of Engabreen. It drains to Fonndalselva river and then to Holandsfjorden.



Map: Norge digitalt



Fonndalsbreen on 9th August 2011. Photo: Hallgeir Elvehøy, NVE.

www.norgeibilder.no (24.08.2008)



Events:

1723 – Glacier length changes. Glacier advance; Fonnøyra farm was severely damaged (Grove, 1988).

1987 – Ice avalanche. NVE-employees observed large ice blocks from an ice avalanche at a considerable distance from the glacier in the valley Fonndalen in May 1987 (Hagen, 1988). Ice must have fallen from an elevation of about 800 m a.s.l. in the spring or early summer. Ice blocks were found at an elevation of 215 m a.s.l., hence the vertical fall was 585 m, and the horizontal reach was 1300 m. The valley was covered by a regenerated glacier between 600 and 280 m a.s.l. Subsequent calculations suggest volume of the ice avalanche was about 300,000 m³.

Monitoring: Regularly observed by NVE. Some investigations of the glacier were made by Knut Hagen (NVE) in 1987 in connection with extensive hydropower construction in the area.

Pictures taken in 1911, 1979, 1982, 1996, 1998, 2001, 2005, 2007-2012.

Future risks: Ice avalanche (Hagen, 1988).

References: Grove, J.M. 1988. *The Little Ice Age. Methuen, London and New York*, pp. 64-107.

Hagen, K. 1988. Rasfare ved Stor-Glomfjordutbyggingen. *NVE-Oppdragsrapport nr. 2-88*, 38p.

NVE glacier database, Norge digitalt, www.norgeibilder.no.

Fortundalsbreen (N)

Location: Luster / Skjåk, Sogn & Fjordane / Oppland.

Latitude: 61.74° N, Longitude: 7.71° E

WGI-ID: N4A000AE018

NVE-Atlas-ID: 2505

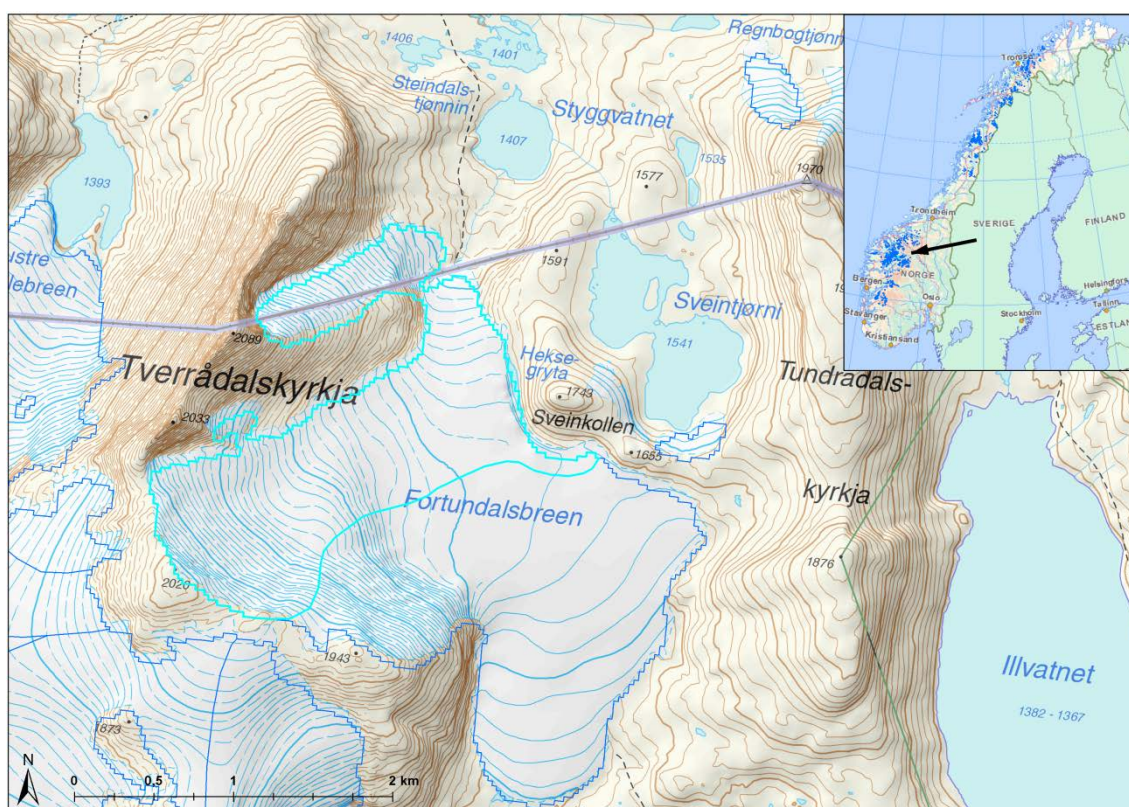
Dimensions: Area: 2.68 km², length: 2.86 km

Altitudinal range: 1487 – 2012 m a.s.l.

Glacier type: Valley glacier

Event type: Potential jøkulhlaup

Description: Northern part of Fortundalsbreen glacier in Breheimen which drains northwards to lake Styggvatn (1407 m a.s.l.). At its eastern side, the glacier dams a glacial lake, Heksegryta, which was about 360 m long and 40 m wide with an area of about 0.01 km² in July 2010 (www.norgebilder.no (07.09.2010), next page).



Map: Norge digitalt



Heksegryta
photographed in 2001.
Photo: Leif Edvin
Wærstad.



Map: Norge digitalt



Probable drainage path of water from the glacier-dammed lake is shown in red. Photo from www.norgebilder.no (07.09.2010)

The size of the glacier-dammed lake Heksegryta in 2010 suggests maximum possible volume 0.05 mill. m³. Drainage path of water from a potential jøkulhlaup is shown above. The maximum volume is small, and the water would drain to lake Styggvatnet, so there is little possibility of extensive damage.

Monitoring: –

Future risks: Potential jøkulhlaup.

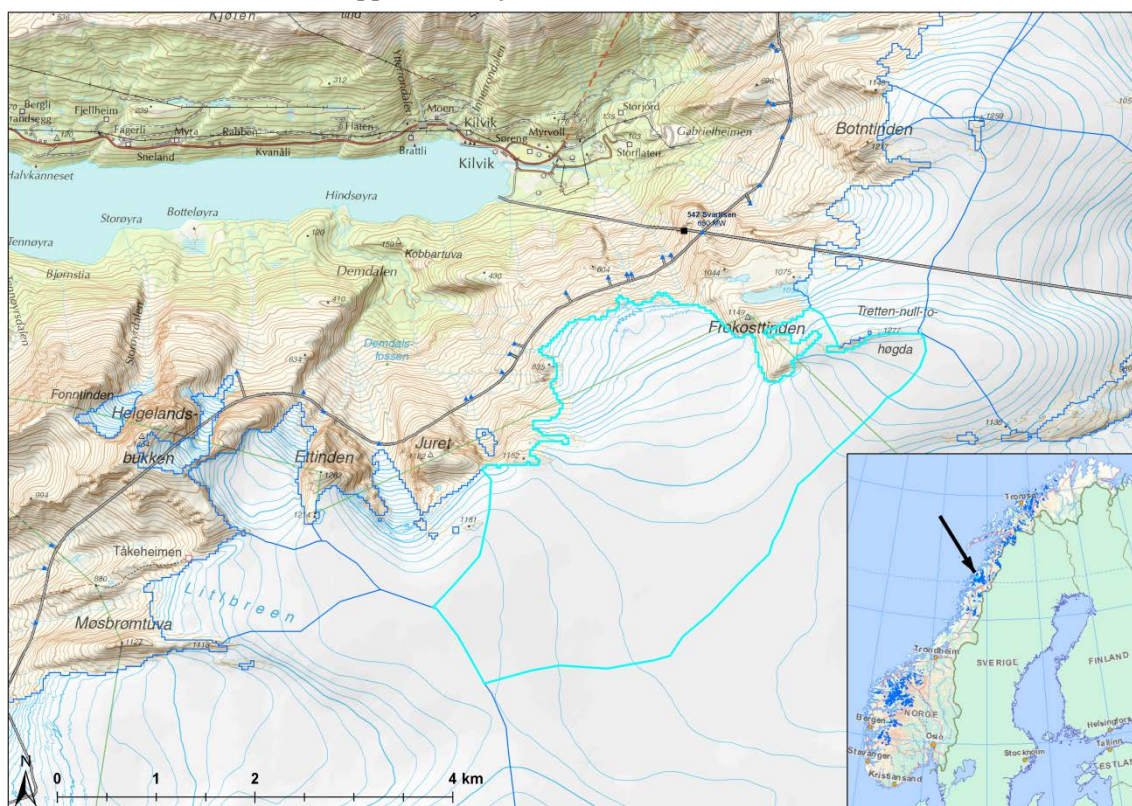
References: NVE glacier database, Norge digitalt, www.norgebilder.no.

Frokosttindbreen

(This name is unofficial and refers to the location of the glacier close to Frokosttinden mountain summit)

Location:	Meløy, Nordland. Latitude: 66.7° N, Longitude: 13.94° E
WGI-ID:	N4A000C4005
NVE-Atlas-ID:	1089
Dimensions:	Area: 10.5 km ² , length: 6 km
Altitudinal range:	742 – 1264 m a.s.l.
Glacier type:	Outlet glacier
Event type:	Ice avalanche

Description: A north-west outlet from Vestre Svartisen ice cap. Frokosttindbreen is situated south-east of the inner part of Nordfjorden fjord, about 2 km south of Kilvik. The glacier tongue lays on a relatively even, but steep slope (ca. 45°), and according to Lied (1987) is not frozen to the bed at least during the summer. The western part of the tongue is less steep and drains to Nordfjorden through Demdalen valley. The northern part of the glacier tongue drains to Nordfjorden through Kilvik and presents a potential danger of ice avalanche for the settlement if the glacier increases in size. This dangerous part of the glacier tongue is about 800 m wide, terminates at an elevation of approximately 800 m a.s.l. and has two small arms.



Map: Norge digitalt



Frokosttindbreen's tongues in October 2001. Photo: Hallgeir Elvehøy, NVE



Frokosttindbreen on 19th August 2002. Photo: Miriam Jackson, NVE.

Events:

Regular – According to local inhabitants in Kilvik (Bjarne Kilvik was interviewed in 1987), there are often minor ice avalanches from Frokosttindbreen in the summer (Lied, 1987).

Monitoring: In connection with hydropower development in the area at the end of the 1980s, NVE ordered an investigation of the risks related to glaciers. The Norwegian Geotechnical Institute (NGI) performed such an investigation on Frokosttindbreen in 1987.

Future risks: Ice avalanche. According to the estimates given in Lied (1987), there were three potential alternatives for ice-avalanche volume:

140,000 m³ (lower part of the western tongue arm described above), 312,000 m³ (the whole arm) and 472,000 m³ (northern part of the glacier tongue together with its arms).

However, due to glacier retreat in recent years the volume of a potential ice avalanche has probably decreased accordingly.

References: Lied, K. 1987. Storglomfjordutbyggingen. Frokosttindbreen. Vurdering av fare for is-skred. NGI-Oppdragsrapport 87479-1, 1987, 43 pp.

NVE glacier database, Norge digitalt.

Frostisen (V)

Location: Ballangen, Nordland.
Latitude: 68.25° N, Longitude: 17.12° E

WGI-ID: N4A000DT008

NVE-Atlas-ID: 743

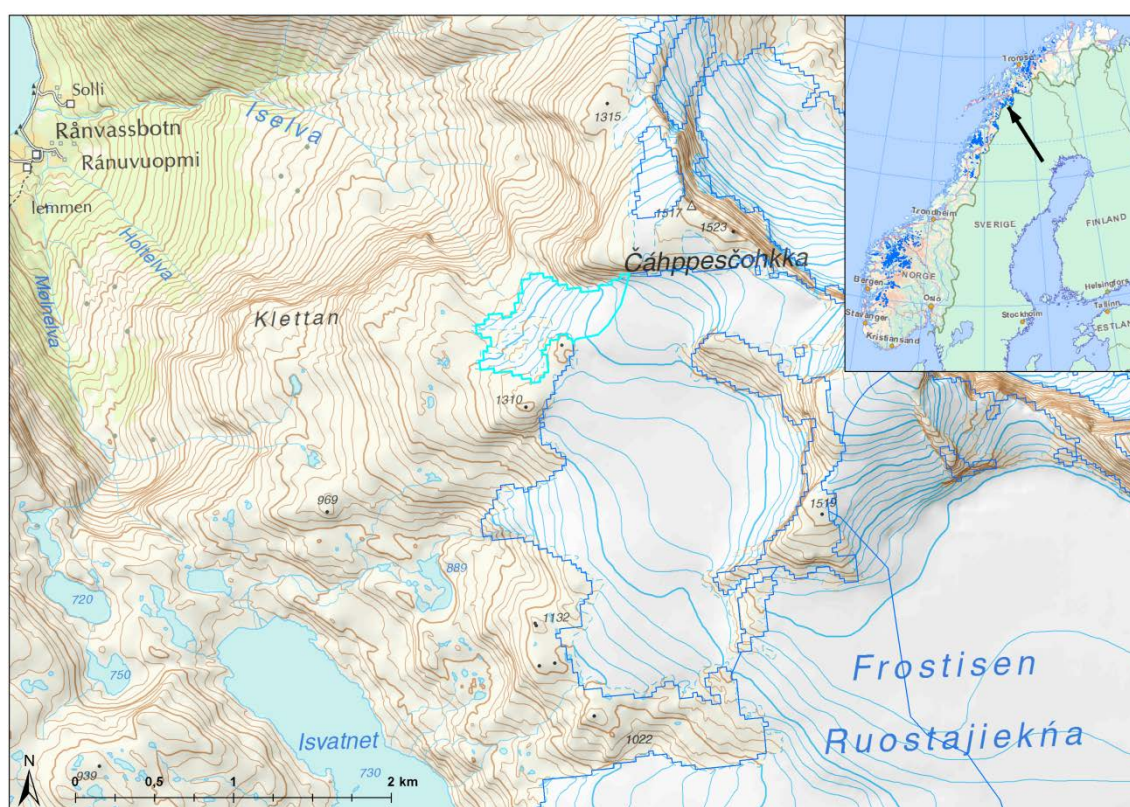
Dimensions: Area: 0.34 km², length: 0.7 km

Altitudinal range: 1144 – 1377 m a.s.l.

Glacier type: Outlet glacier

Event type: Glacier length change, Ice avalanche

Description: Small north-western outlet from Frostisen (Ruostajiekhá) ice cap. Frostisen (V) lies to the west of Čáhpesčohkka mountain summit (1523 m a.s.l.), south of Ofotfjorden and about 25 km southwest of Narvik. The glacier drains to Iselva river and then to Storvatnet lake.





www.norgebilder.no (22.08.2010).

Events:

Ca. 1900 – Glacier length change. Around the turn of the last century, a lot of ice avalanches took place. In just one day, six avalanches were registered. The biggest was in 1906, when at least 7,000 cubic metres of ice fell. An outlet of the glacier caused icefalls on a steep hillside (Hoel and Werenskiold, 1962).

Monitoring: –

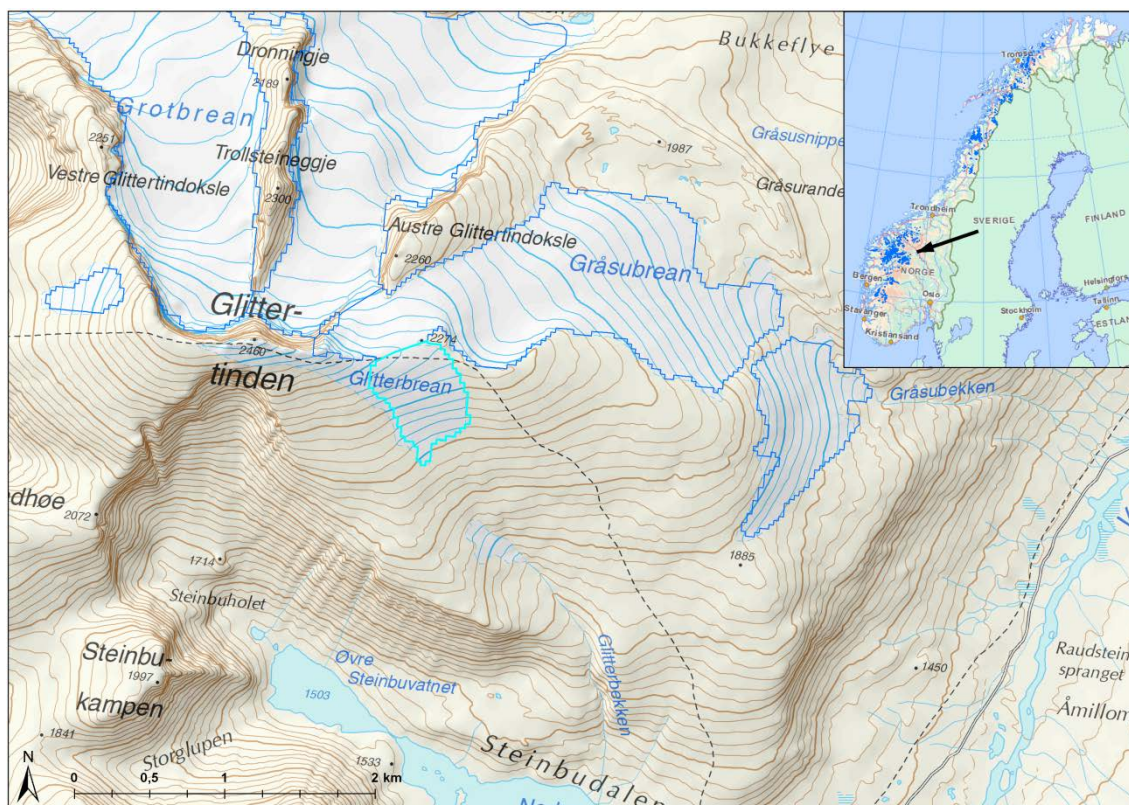
Future risks: The danger disappeared a few years after the 1906 events, when the ice-cone had melted (Hoel and Werenskiold, 1962).

References: Hoel, A. and Werenskiold, W. 1962. Glaciers and snowfields in Norway. *Norsk Polarinstitutt Skrifter*, Nr. 114, 1962. 291 p.

NVE glacier database, Norge digitalt, www.norgebilder.no.

Glitterbrean

Location:	Lom, Oppland. Latitude: 61.65° N, Longitude: 8.58° E
WGI-ID:	N4A000AD003
NVE-Atlas-ID:	2745
Dimensions:	Area: 0.33 km ² , length: 0.9 km
Altitudinal range:	2093 – 2302 m a.s.l.
Glacier type:	Glacieret – snow field
Event type:	Mountaineering accident
Description:	Eastern Jotunheimen, south-east of Glittertinden, the second highest mountain peak in Norway. A snow field leads to the summit. The glacieret is connected to the southern boundary of Gråsubrean glacier.



Map: Norge digitalt



Glitterbreen photographed on 1st October 2007. Photo: Morten Helgesen, <http://fjelletibilder.no/>

Events:

16/07/2001 – Mountaineering accident. A British man fell and slid 250 metres down a steep snowfield (35°). He hit a small area of rocks and died. His son went for help. They both used ice axes, but probably had insufficient training. The body was retrieved by helicopter. Temperature +3 °C and wet snow (Norges Klatreforbund).

Monitoring: –

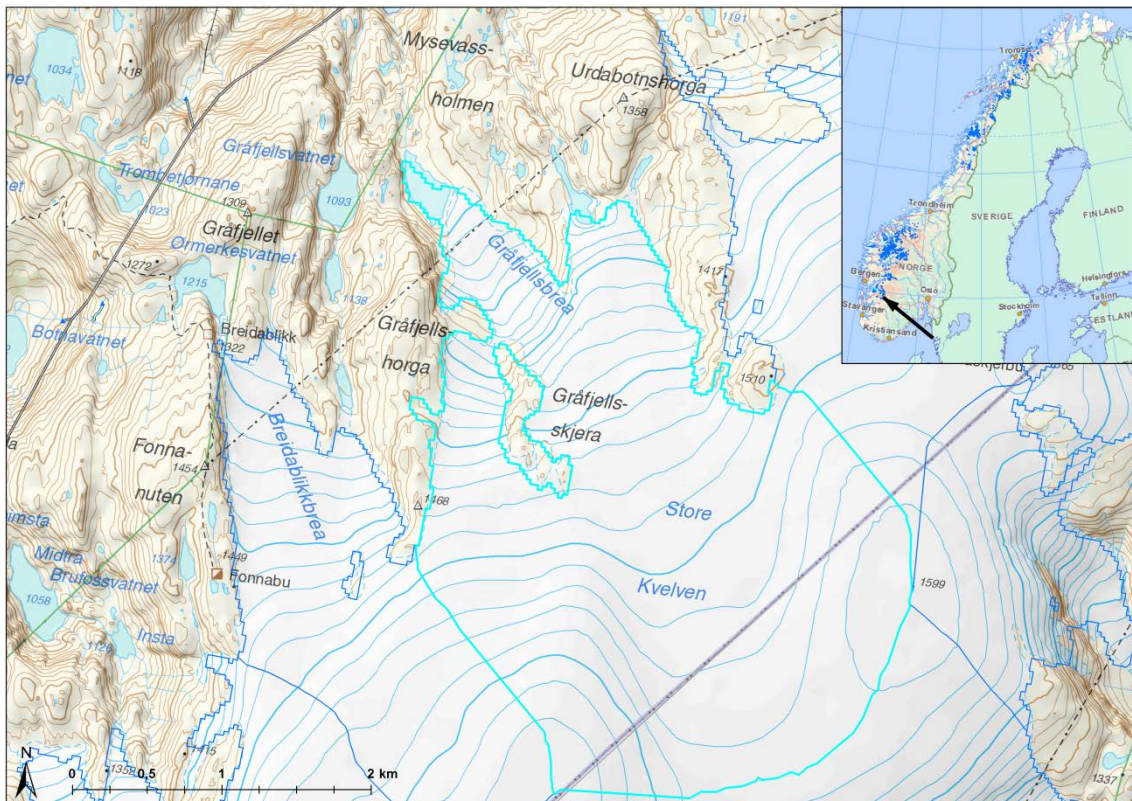
Future risks: Steep snow is always potentially dangerous for inexperienced people.

References: Norges Klatreforbund.

NVE glacier database, Norge digitalt, <http://fjelletibilder.no/>.

Gråfjellsbrea

Location:	Kvinnherad, Hordaland. Latitude: 60.08° N, Longitude: 6.41° E
WGI-ID:	N4A000AK007
NVE-Atlas-ID:	3127
Dimensions:	Area: 8.77 km ² , length: 5.43 km
Altitudinal range:	1078 – 1645 m a.s.l.
Glacier type:	Outlet glacier
Event type:	Potential jøkulhlaup
Description:	An outlet glacier from Søndre Folgefonna ice cap, north-east of Breidablikkbreen. The glacier drains north to Austrepollen bay in Maurangsfjorden through the lake/hydropower reservoir Mysevatnet and the river Austrepolleva.



Map: Norge digitalt



www.norgebilder.no (16.07.2006)

On its eastern tongue, Gråfjellsbrea dams an unnamed glacial lake. The size of the lake is estimated to be about 0.02 km² which suggests a possible volume of water of 0.1 mill. m³.

Monitoring: Mass balance measurements in 1964-68, 1974-75, 2003-12.
Front position measurements since 2002.
Detailed map surveys in 1959, 1997 and 2007.

Future risks: Potential jøkulhlaup.

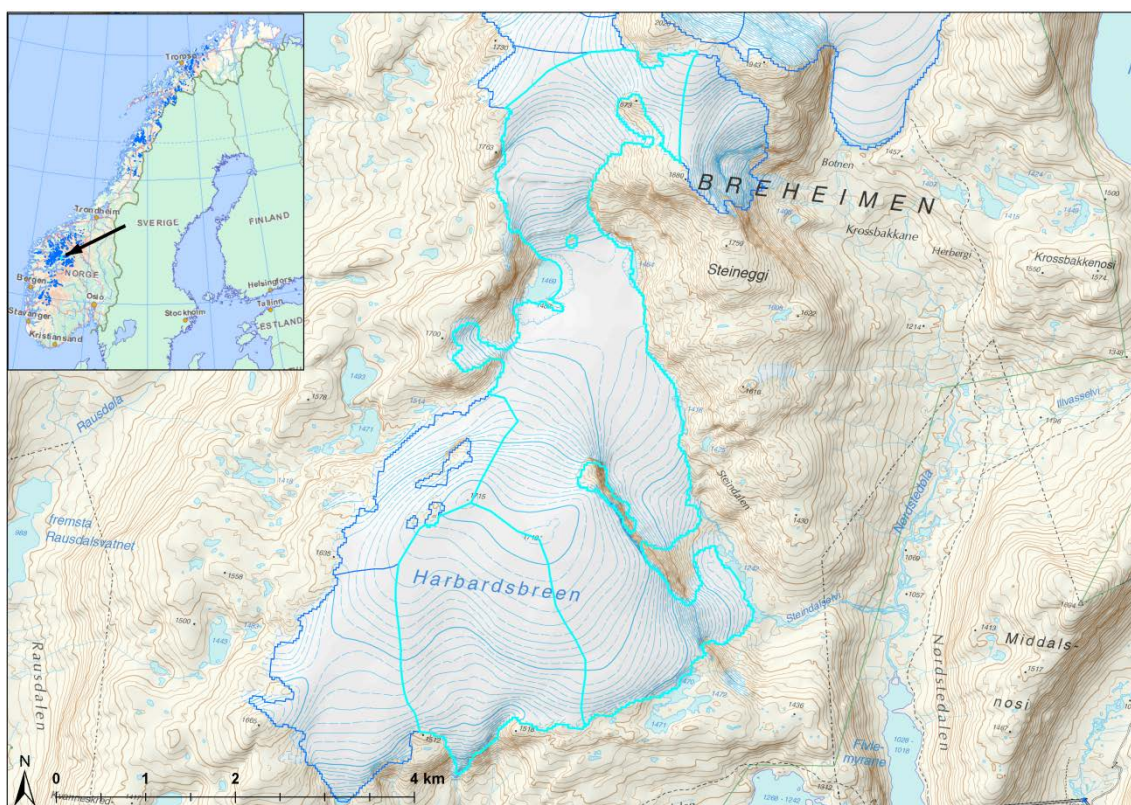
References: NVE glacier database, Norge digitalt, www.norgebilder.no.

Harbardsbreen (Ø and S)

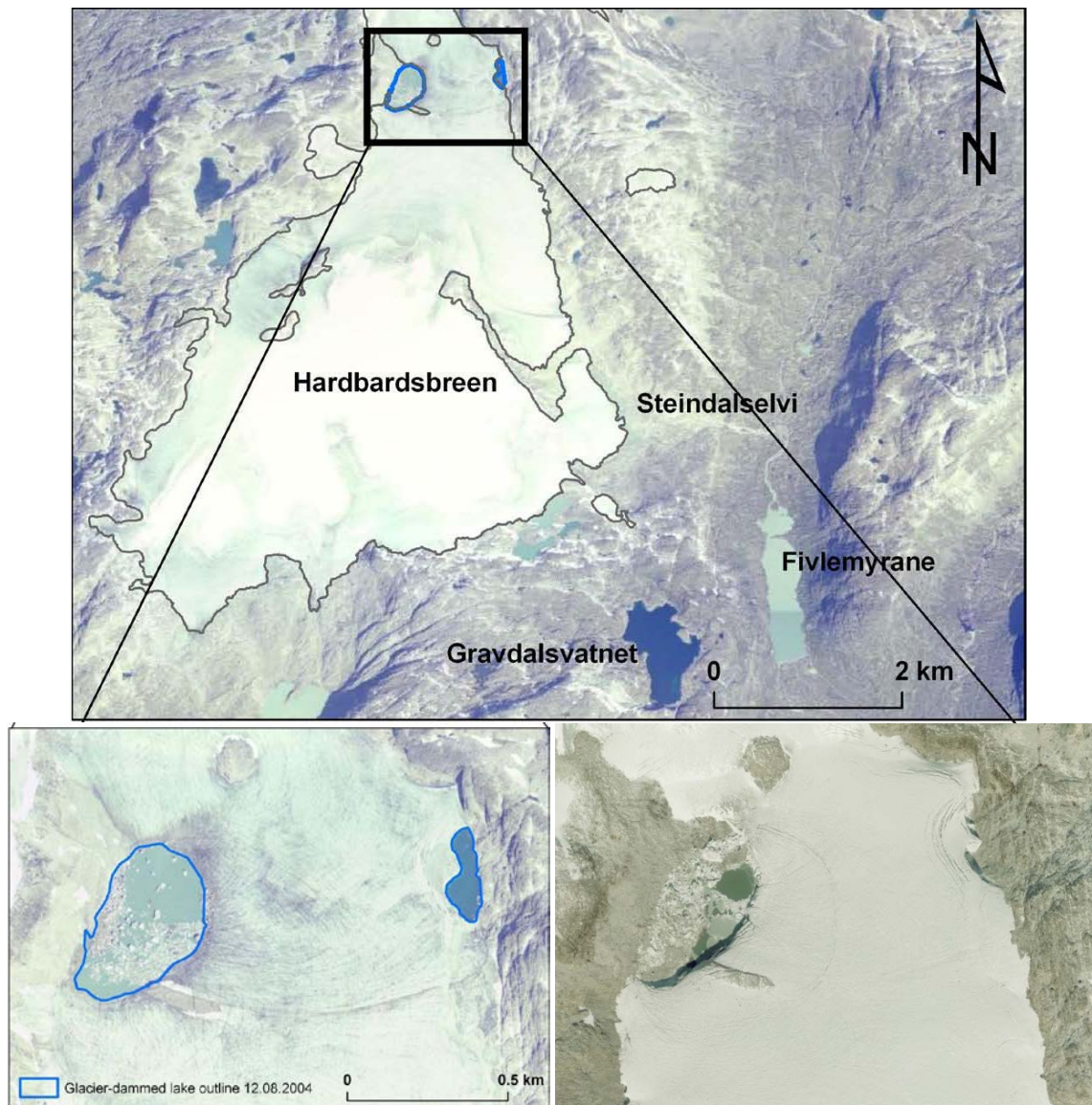
Location:	Luster, Sogn & Fjordane. Latitude: 61.68° N, Longitude: 7.67° E
WGI-ID:	N4A000A2004/ N4A000A2003
NVE-Atlas-ID:	2514 and 2516
Dimensions:	Area: 11.3 and 4.4 km ² , length: 7.0 and 3.1 km
Altitudinal range:	1265 – 1957 m a.s.l.
Glacier type:	Plateau glacier
Event type:	Jøkulhlaup, Mountaineering accident

Description: Harbardsbreen is a plateau glacier in an area known as Breheimen, east of the Jostedalsgreen ice cap and west of Jotunheimen. The central part drains eastward to the river Steindalselvi, into Fivlemyrane reservoir and then to the river Fortundalselvi, whereas the southern part drains down to Leirvatnet lake.

In the central part, the glacier dams two unnamed lakes at elevations of 1464 m a.s.l. (smaller lake) and 1469 m a.s.l. (larger lake, known to be the source of a several jøkulhlaups).



Map: Norge digitalt



www.norgebilder.no (12.08.2004)

www.norgebilder.no (26.09.2010)

Events:

October 1996 – Jøkulhlaup. Positive effects.

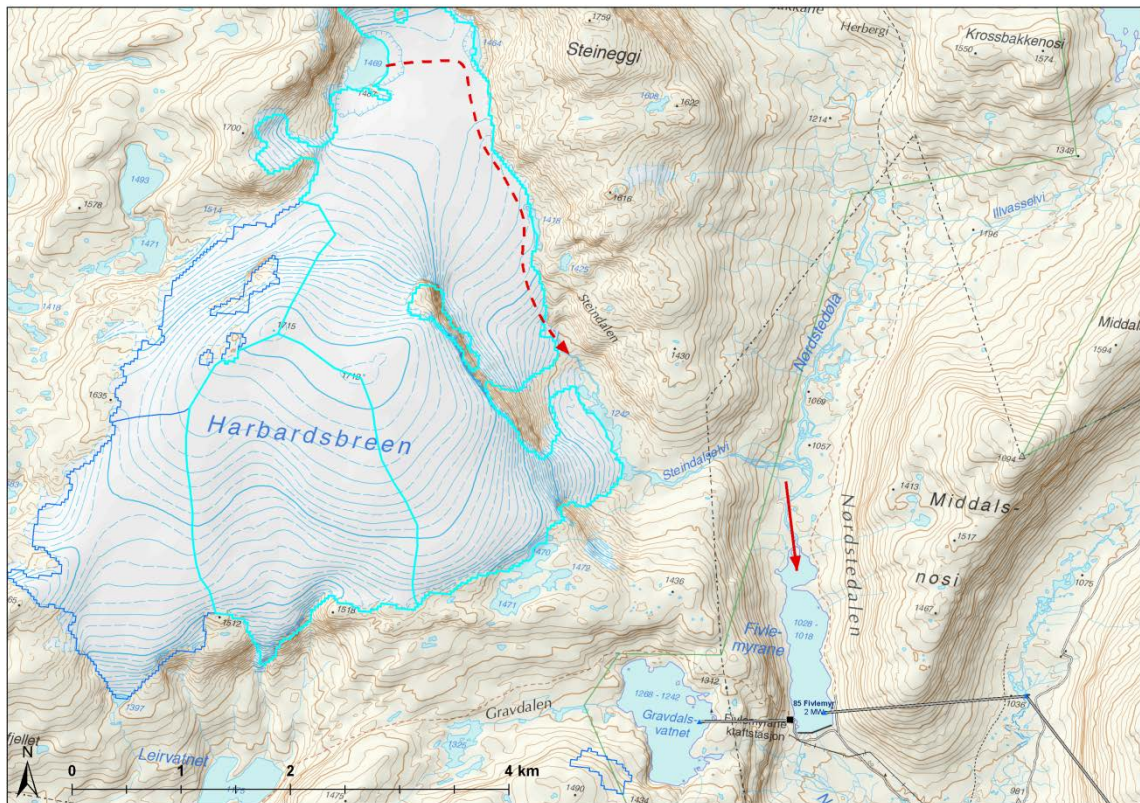
October 1997 – Jøkulhlaup. Positive effects.

October 1998 – Jøkulhlaup. Positive effects.

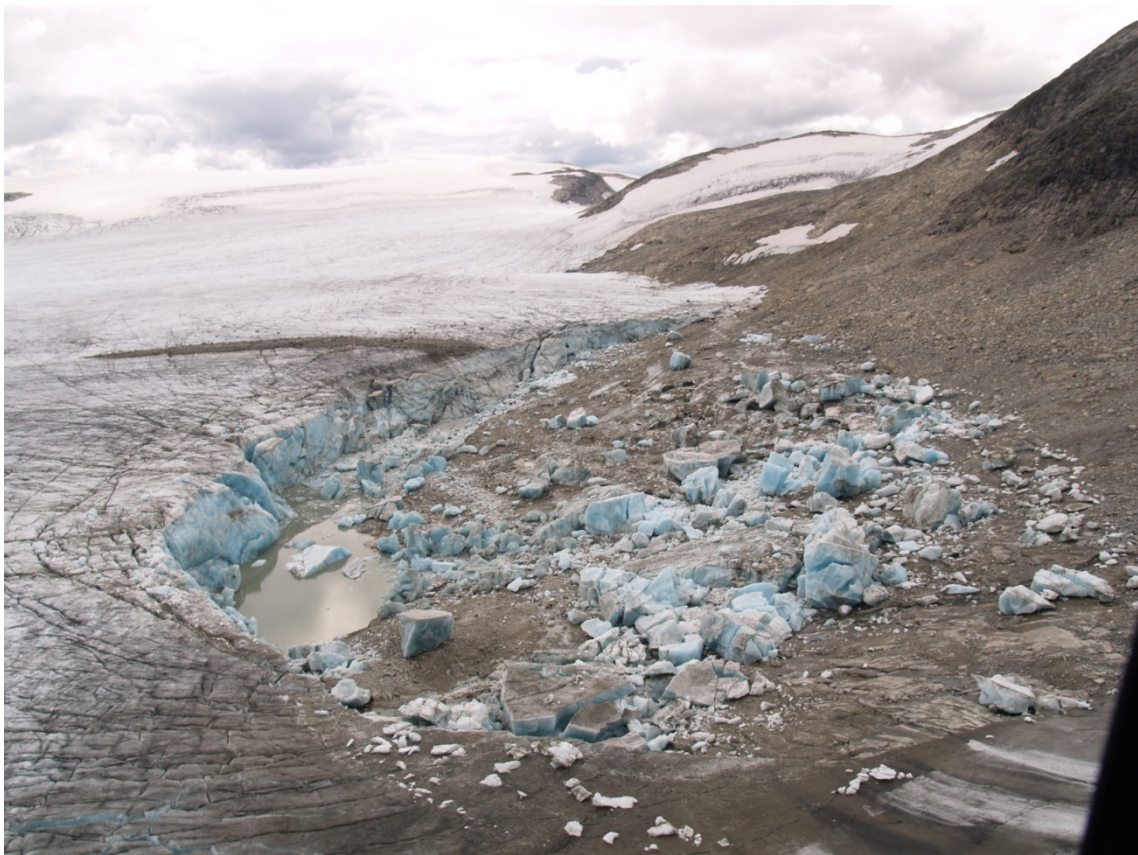
October 2000 – Jøkulhlaup. Positive effects.

27/06/2001 – Mountaineering accident. A 34 year old Swedish man fell into a seven metre deep crevasse only 30 metres from the edge of Harbardsbreen. His two friends went for help, but he died later at hospital. They did not use rope, and were not adequately equipped for glacier travel (NRK nyheter 29/06/01).

October 2001 – Jøkulhlaup. Positive effects.



Map: Norge digital. Path of previous and potential future jökulhlaups is shown in red.



Drained glacial lake on Harbardsbreen photographed on 9th August 2010. Photo: Rune Engeset, NVE

04/08/2010 – Jøkulhlaup. The total water volume was about 5.5 million m³. The flood caused the hydropower reservoir downstream from the glacier to overflow and evacuation along the river in the valley Fortundalen was considered but not implemented (Engeset, 2010; Kjøllmoen et al., 2011).

Monitoring: Mass balance measurements 1997-2001. Regularly observed by NVE. Pictures taken in 1992-2002, 2010, 2012. Detailed map surveys in 1966, 1996 and 2010.

Future risks: Jøkulhlaup. Although there is a hydropower reservoir downstream that can accommodate some additional water, if the flood is very large then this will overflow and may affect inhabitants in Fortundalen.

References: Engeset, R.V. 2010. Jøkulhlaup fra Harbardsbreen til Fivlemyrane magasin i august 2010. *NVE-Notat av 11.08.2010*.

Kjøllmoen, B., L.M. Andreassen, H. Elvehøy, M. Jackson and R.H. Giesen. 2011. Glaciological investigations in Norway in 2010. *NVE-report no 3*, 2011.

Kjøllmoen, B. and R.V. Engeset. 2003. Glasiologiske undersøkelser på Harbardsbreen 1996-2001. *Oppdragsrapport nr 1*. Sluttrapport.

NRK nyheter 29/06/01.

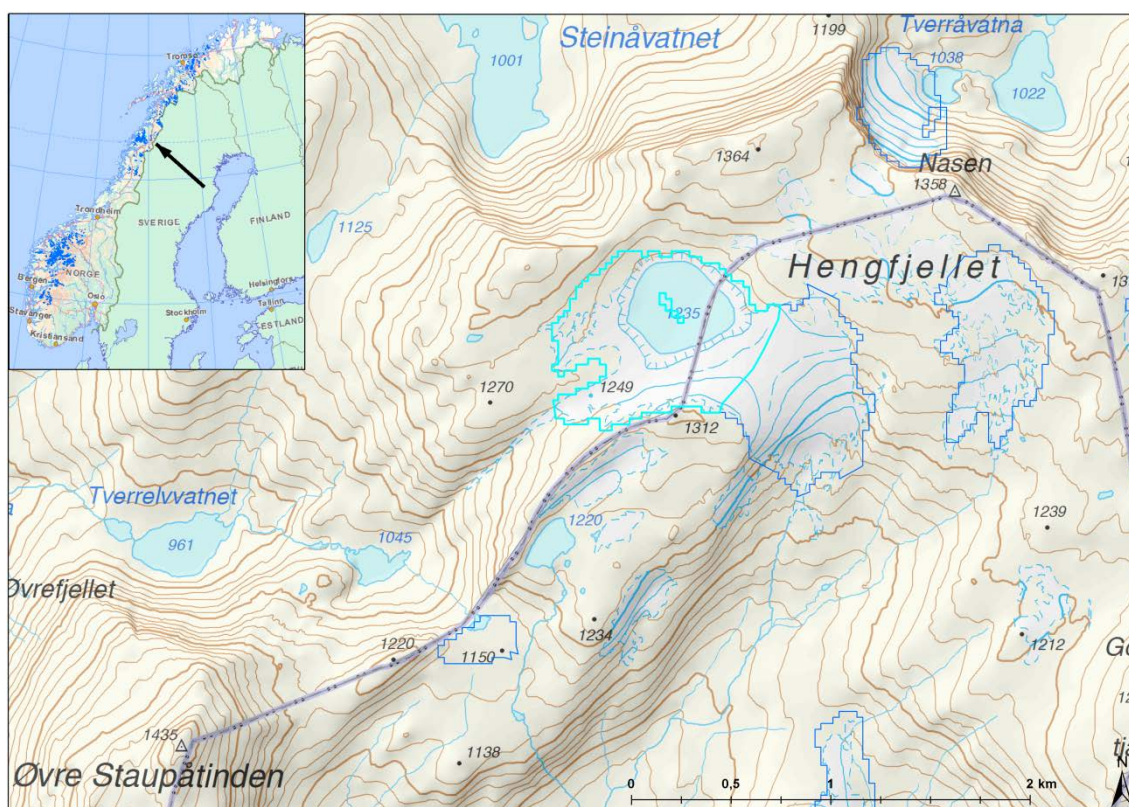
NVE glacier database, Norge digitalt.

Hengfjellet glacier (W)

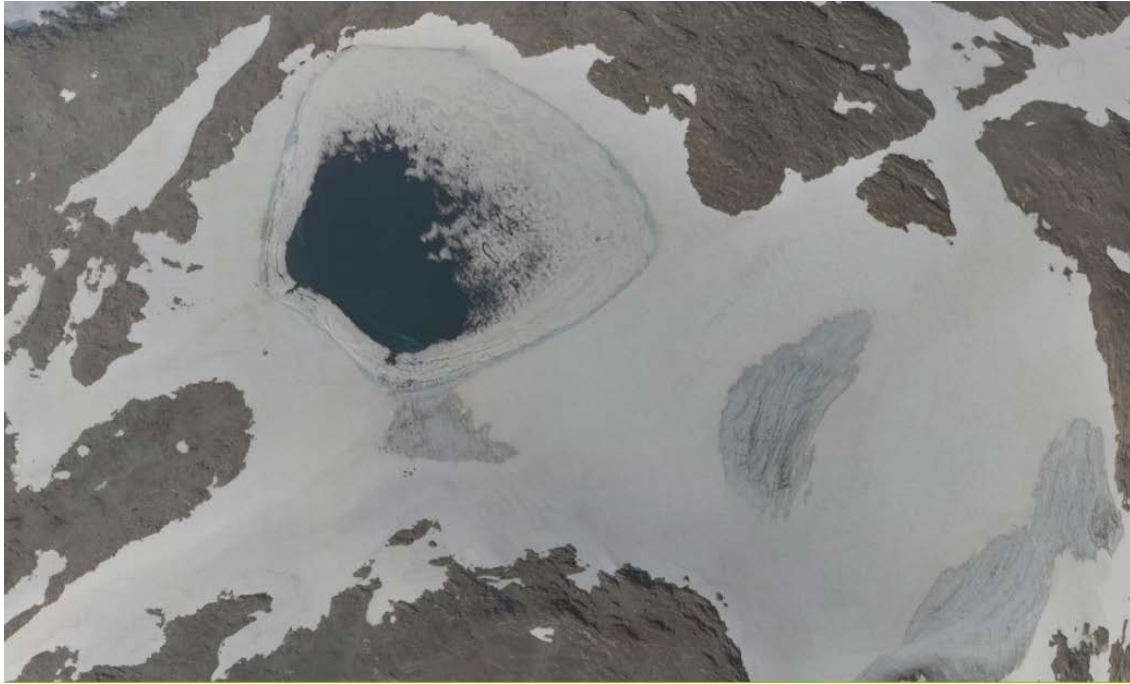
(This name is unofficial and refers to the location of the glacier west of Hengfjellet)

Location:	Beiarn / Rana, Nordland. Latitude: 66.75° N, Longitude: 14.67° E
WGI-ID:	N4A000DE003
NVE-Atlas-ID:	1260
Dimensions:	Area: 0.7 km ² , length: 1.2 km
Altitudinal range:	1236 – 1301 m a.s.l.
Glacier type:	Cirque glacier
Event type:	Potential jøkulhlaup

Description: Western part of an unnamed glacier near the mountain Hengfjellet. It is situated on the eastern side of the valley Beiarn dalen, where it drains through a series of small lakes (including Tverrelvvatnet) and rivers Tverråga and Staupåga to the river Beiarelv. The special feature of this glacier is the existence of a supraglacial lake which is about 0.5 km in diameter.



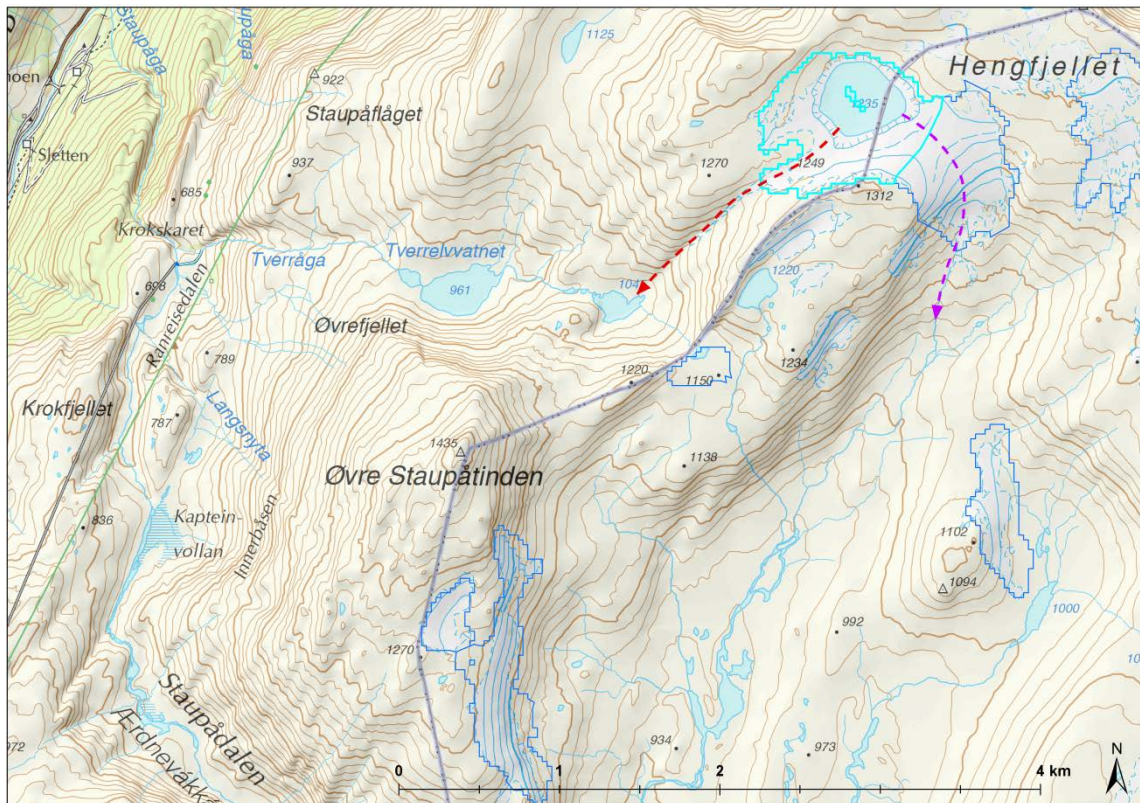
Map: Norge digitalt



www.norgeibilder.no (24.08.2008)

In 1988, Jim Bogen (NVE) found sediments indicating a catastrophic jøkulhlaup at least once in the past from a supraglacial lake on Hengfjellet glacier (W) (Vaksdal and Melvold, 2003). The size of the lake is about 0.2 km², which suggests maximum possible volume of water 1 million cubic metres.

The following figure shows two potential drainage pathways from the lake (shown in red and purple). Note that depending on the particular drainage path the water takes, which in turn depends on the subglacial topography, the water would end up in two entirely different directions – either south and then west through the lake Tverrelvvatn and subsequently into the river Beiar, or east and then south, to the river Blakkåga. There appears to be no immediate danger to structures or people, although a more thorough investigation is necessary for this to be fully assessed.



Map: Norge digitalt

Monitoring: –

Future risks: Jøkulhlaup.

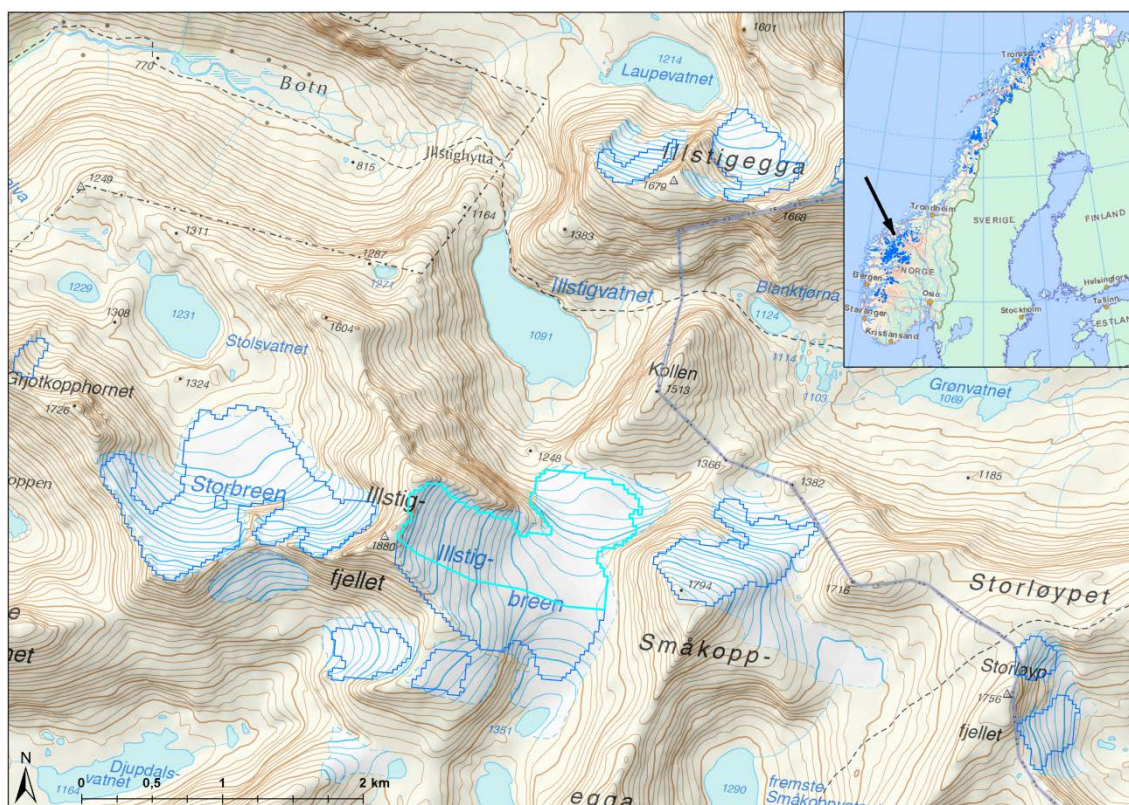
References: Vaksdal, M. and K. Melvold. 2003. Glacier Inventory in Norway. *Glaciorisk. EVG1 2000 00512*. Final report (2001-2003):
http://glaciorisk.grenoble.cemagref.fr/sec6_GLACIORISK_Other_Appendices.pdf
 NVE glacier database, Norge digitalt, www.norgebilder.no.

Illstigbreen

Location:	Norddal, Møre & Romsdal. Latitude: 62.25° N, Longitude: 7.61° E
WGI-ID:	N4A000B8004
NVE-Atlas-ID:	1824
Dimensions:	Area: 0.98 km ² , length: 1.9 km
Altitudinal range:	1290 – 1861 m a.s.l.
Glacier type:	Valley glacier
Event type:	Jøkulhlaup

Description: Illstigbreen glacier is situated above Muldal in Tafjord in Sunnmøre. It terminates about 600 m above the eastern part of Illstigvatnet, south of the watershed to Romsdal. The glacier is surrounded by mountain summits Illstigfjellet (1880 m a.s.l.) and Kollen (1513) and a mountain ridge Småkoppegga.

Before Illstigbreen retreated, there was a glacier-dammed lake about 1 km south-east of Illstigvatnet. This lake – Koldevatn (Kollevatnet) – collected meltwater from the glacier and initially flowed east to Grøndølin and Hånådalen (Ulvådalen) valleys (Roald, 2011).



Map: Norge digitalt



www.norgebilder.no (17.09.2011)

Events:

1932 – Jökulhlaup from lake Koldevatn. 3.6 million cubic metres of water with a water discharge of 31 m³/sec at the flood maximum. The lake emptied in about 32 hours (Liestøl, 1956). The jökulhlaup caused a flood in the lower part of Muldalen (Tafjordseterdalen) valley. The water swept away a bridge at Muldal-Tafjordsætra and destroyed Muldalsgårdene farms (Roald, 2011).

1934 – Jökulhlaup from lake Koldevatn. After the first jökulhlaup in 1932, a retaining wall was built to protect against such floods, but was insufficient to contain the quantity of water from this event (Roald, 2011).

Monitoring: In 1935-36 NVE built a rock dam at Illstigvatnet lake so that the water level could rise 3-4 m before it flooded over. An artificial cleft about 1 m wide and 3 m high was made so that the water could run out of here in a more controlled manner (Roald, 2011).

In the 1950s a narrow groove at the outflow of Illstivatnet was constructed such that this lake, formerly a regulating reservoir for potential floods, became more effective.

Future risks: From maps it can be seen that Lake Koldevatn is not a hazard at present, but if the glacier advances the lake may start to fill again.

References: Liestøl, O. 1956. Glacier Dammed Lakes in Norway. *Norsk geografisk tidsskrift* nr. 3-4. Bind XV, 1955-1956, h. 3-4.

Roald, L. 2011. Jökulhlaupene i Muldalsfossen. *NVE database (unpublished)*.

Vaksdal, M. and K. Melvold. Glacier Inventory in Norway. *Glaciorisk. EVG1 2000 00512*. Final report (2001-2003):

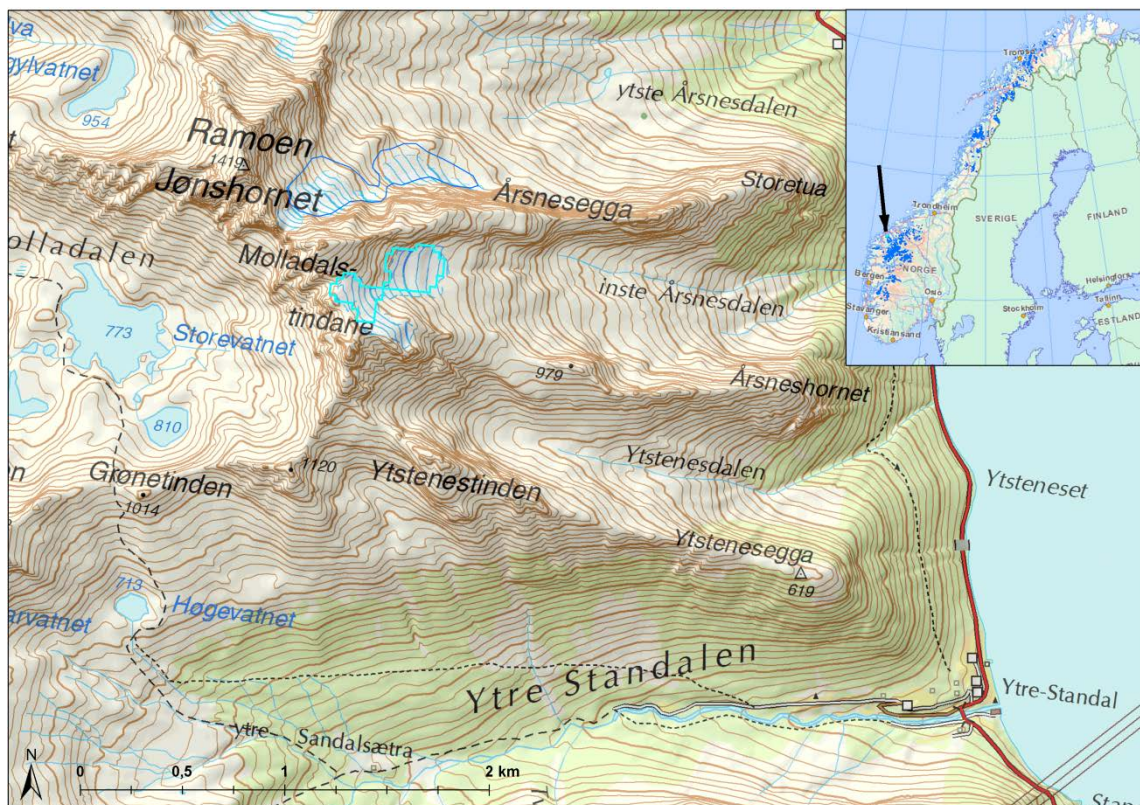
http://glaciorisk.grenoble.cemagref.fr/sec6_GLACIORISK_Other_Appendices.pdf

NVE glacier database, Norge digitalt, www.norgebilder.no.

Inste Årsnesdalsbreen

(This name is unofficial and refers to the location of the glacier uppermost in the valley of Inste Årsnesdalen)

Location:	Ørsta, Møre & Romsdal. Latitude: 62.31° N, Longitude: 6.35° E
WGI-ID:	N4A000BW023
NVE-Atlas-ID:	1971
Dimensions:	Area: 0.09 km ² , length: 0.60 km
Altitudinal range:	1026 – 1302 m a.s.l.
Glacier type:	Cirque glacier
Event type:	Mountaineering accident
Description:	Tiny unnamed cirque glacier leading to the summit of mount Jönshornet west of Hjørundfjorden, south of Ålesund, Møre & Romsdal.



Map: Norge digitalt



www.norgebilder.no (15.09.2006)

Events:

20/10/2001 – Mountaineering accident. A 41 year old man died after a fall into a 7-8 metre deep crevasse. His 27 year old female friend went for help, but became injured herself (broken bones) when she fell. It was too dark for helicopter-transport, so there was no rescue operation until the next day (Aftenposten 22/10/2001).

Monitoring: –

Future risk: Popular alpine mountains in this area. The usual risks apply for glacier walking and ice climbing.

References: Aftenposten 22/10/2001.
NVE glacier database, Norge digitalt, www.norgebilder.no.

Jostedalsbreen (V)

Location: Luster, Sogn & Fjordane.
Latitude: 61.58° N, Longitude: 6.83° E

WGI-ID: N4A000BQ017

NVE-Atlas-ID: 2332

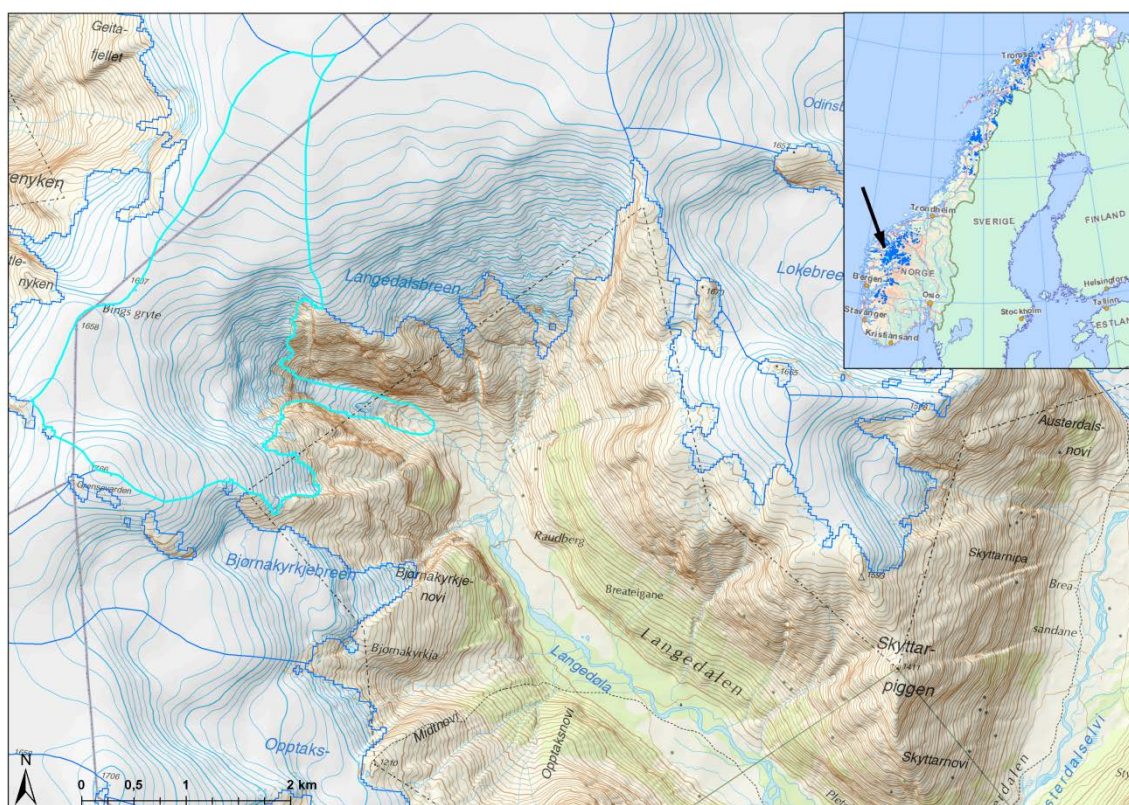
Dimensions: Area: 6.81 km², length: 5.1 km

Altitudinal range: 425 – 1802 m a.s.l.

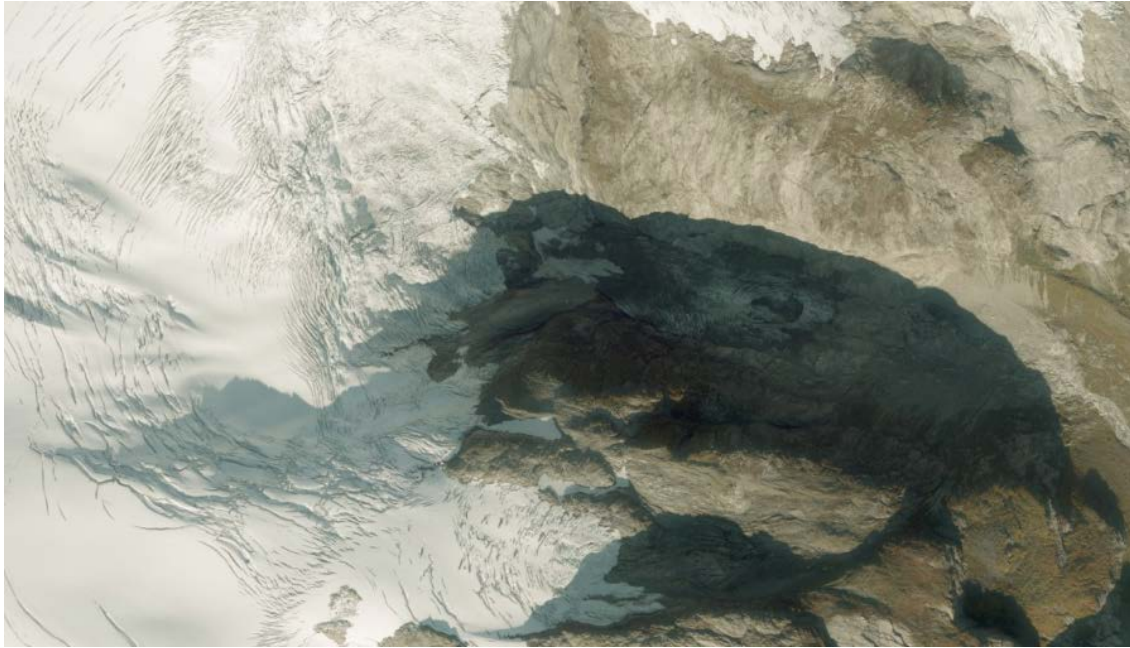
Glacier type: Outlet glacier

Event type: Mountaineering accident

Description: Eastern outlet of Jostedalsbreen. This glacier does not have a name. It is situated between Bjørnakyrkjebreen glacier to the south and Langedalsbreen glacier to the north-east. The glacier drains to Langedøla river in Langedalen valley. There was a tunnel on the glacier tongue that collapsed, and there is an opening in the glacier body about 150 m long at a distance of about 100 m from the glacier front.



Map: Norge digitalt



www.norgebilder.no (26.09.2010)

Events:

29/07/2000 – Mountaineering accident. Man (33) misjudged conditions, slipped and lost control during training of glissade on steep snow, hit a rock and fell into a bergschrund and hit another big rock. Result: broken thigh-bone. Rescued by helicopter (Norges Klatreforbund). There is some uncertainty concerning the location of the accident and it may have occurred on a neighbouring glacier.

Monitoring: –

Future risks: The usual risks apply for glacier walking and ice climbing.

References: Norges Klatreforbund.

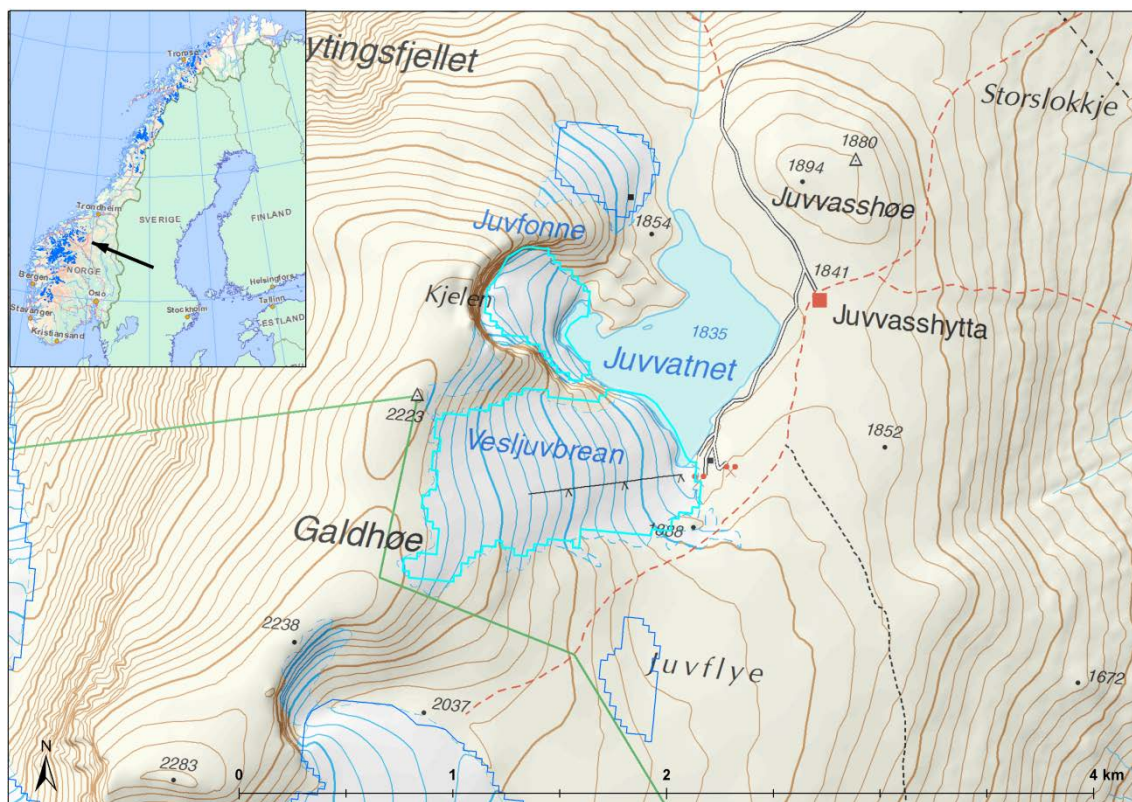
NVE glacier database, Norge digitalt, www.norgebilder.no.

Juvbreen (Veslgjuvbreen and Kjelen)

Location:	Lom, Oppland. Latitude: 61.66° N, Longitude: 8.35° E
WGI-ID:	N4A000AD025 and N4A000AD026
NVE-Atlas-ID:	2601 and 2598
Dimensions:	Areas: 0.8 and 0.18 km ² , lengths: 1.5 and 0.4 km
Altitudinal range:	1835 – 2198 m a.s.l.
Glacier type:	Cirque glacier and mountain glacier
Event type:	Mountaineering accident

Description: The glacier was previously a single glacier unit called Juvbreen, and was reported as such in an article relating to the event. The glacier has since split into two distinct units, and it is not clear from the newspaper article exactly where the accident occurred and hence which unit.

The glaciers are north of Styggebreen glacier in central Jotunheimen, 5 km northeast of Galdhøpiggen, Norway's highest mountain peak (2469 m.a.s.l.). Veslgjuvbreen and Kjelen terminate into Juvvatnet lake. There is an alpine ski centre on the small glacier of Veslgjuvbreen and a tourist road along the south-eastern side of the glacier from Juvvasshytta tourist cabin.



Map: Norge digitalt



www.norgebilder.no (12.08.2004)

Events:

10/07/1957 – Mountaineering accident. A 15 year old Danish girl, Inge Mauritsen from Copenhagen, fell into a 50 m deep crevasse and died (Aftenposten 12/07/1957). Her body was not found but footprints were seen leading to the crevasse.

Monitoring: Employees at Galdhøpiggen Sommerskisenter observe critical glacial changes. Mass balance and glacier length changes measurements on Juvfonna (north of Kjelen) from 2010. Detailed map survey in 2011.

Future risks: There is an alpine ski centre on this small glacier, so there are many people there during the summer. The glacier is virtually stagnant so there is little risk.

References: Aftenposten 12/07/1957.
Galdhøpiggen Sommerskisenter.
NVE glacier database, Norge digitalt, www.norgebilder.no.

Kjenndalsbreen

Location: Stryn, Sogn & Fjordane.
Latitude: 61.71° N, Longitude: 7.03° E

WGI-ID: N4A000BT023

NVE-Atlas-ID: 2296

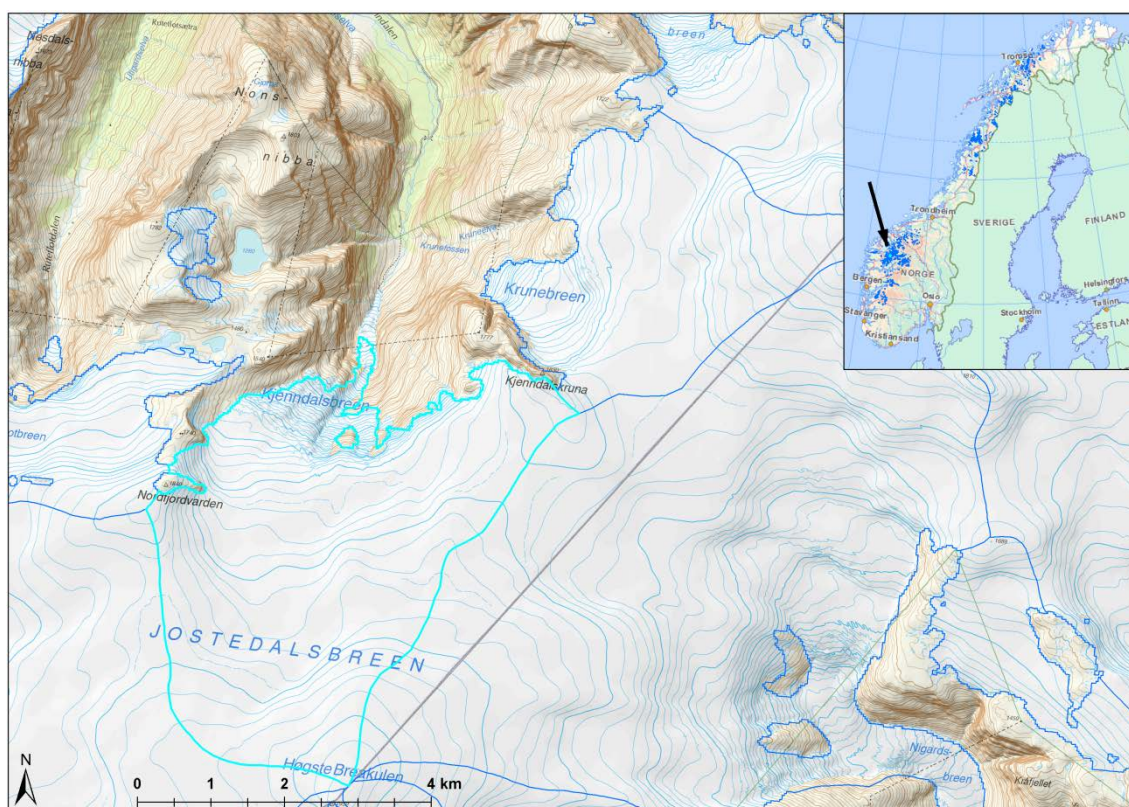
Dimensions: Area: 19.07 km², length: 9.0 km

Altitudinal range: 489 – 1948 m a.s.l.

Glacier type: Outlet glacier

Event type: Glacier length change

Description: One of the northern outlets from the central part of Jostedalsbreen icecap, situated between Ruteflotbreen glacier to the west and Krunebreen glacier to the north-east. Kjenndalsbreen drains to Lovatnet lake through Kjenndalen valley. There is a road to within about 1 km of the glacier tongue, and a walking path all the way to the glacier.



Map: Norge digitalt



Kjenndalsbreen photographed on 2nd September 2009. Photo: Hallgeir Elvehøy, NVE

Events:

1667 - 1693 – Glacier length change (advance). Farmland in Kjenndalen (Tiørdal) valley was completely ruined “by the destructive glacier and by the great river running from it”. Five enclosures and six barns were completely carried away (Grove, 1988).

Monitoring: Monitored by NVE. Pictures taken in 1872, 1888, 1890-1900 and on a regular basis from 1991.

Future risks: Minor risk of ice avalanche as the glacier is easily accessible and in a popular tourist area. Potential risk due to glacier length change if the glacier did advance again, although little infrastructure in the immediate vicinity.

References: Grove, J.M. 1988. *The Little Ice Age. Methuen, London and New York*, pp. 64-107.

NVE glacier database, Norge digitalt.

Koppangsbreen

Location: Lyngen, Troms.
Latitude: 69.69° N, Longitude: 20.14° E

WGI-ID: N4A000EH087

NVE-Atlas-ID: 205

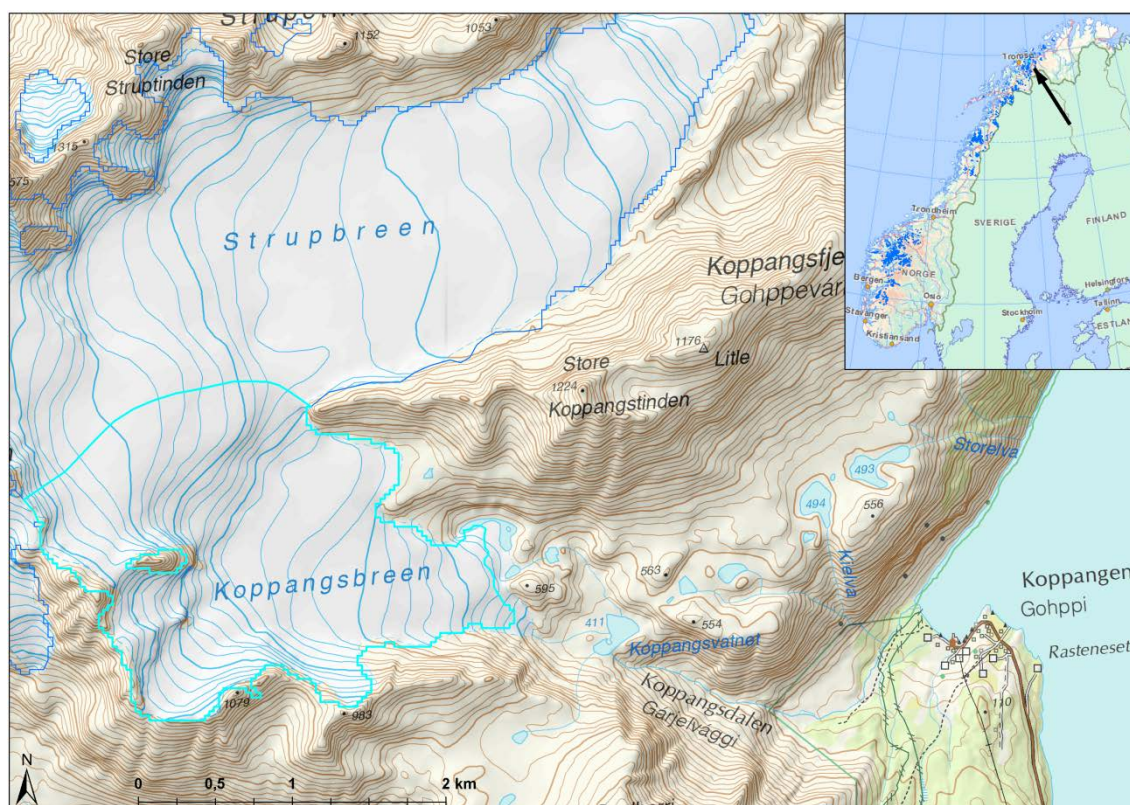
Dimensions: Area: 4.14 km², length: 4 km

Altitudinal range: 509 – 1203 m a.s.l.

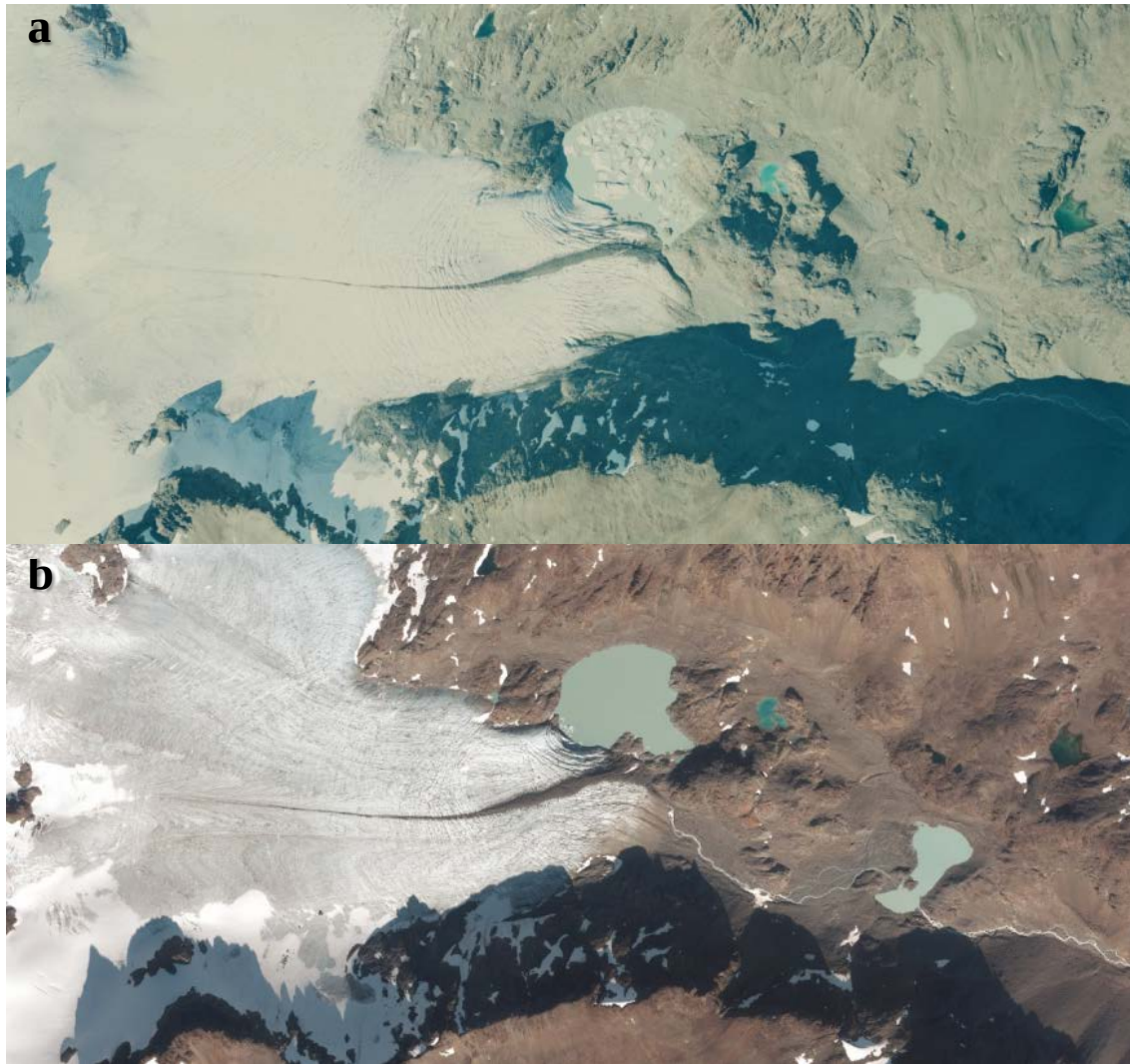
Glacier type: Valley glacier

Event type: Jøkulhlaup

Description: Koppangsbreen is a valley glacier, situated on Lyngen peninsula to the south of Strupbreen glacier and east of Tafeltinden glacier horn (1395 m a.s.l.). Koppangsbreen drains to Koppangsvatnet lake and further towards Koppangen village.



Map: Norge digitalt



www.norgebilder.no: **a** – 27.07.2006, **b** – 16.08.2011.

Events:

06/09/2010 – Jøkulhlaup. Glacier-dammed lake adjacent to the glacier tongue drained under the glacier causing an unexpected flood in the river Koppangselva on Lyngen in Troms county. The river consequently took a new course, such that a house at Koppangen became cut-off and was in danger of being flooded. The glacier front has retreated more than 200 m since 1998 as the glacier has become smaller, and the glacier-dammed lake has grown correspondingly.

2011 – Jøkulhlaup, date unknown. Smaller than in 2010.

2012 – Jøkulhlaups, first in summer and second in late September or early October. Both minor.

04/06/2013 – Jøkulhlaup. Almost 2 million cubic metres of water from a glacier-dammed lake. Several houses had to be evacuated. The event lasted eleven hours.



Norge digitalt (27.07.2006). The blue arrows show where the water flowed during the first 2013 event.

2013 – Several more events over the next four weeks lasted between one and two hours and presumably the total amount of water released was considerably less. The events occurred

on 09/06/2013, 19/06/2013, 23/06/2013, 26/06/2013, 30/06/2013 and 3/7/2013, 12/08/2013 and 03/09/2013.

17/6/2014 – Jøkulhlaup. The event probably started late in the evening, and increased discharge was first recorded about 11 pm.

Date	Time	Duration
6 September 2010	-	-
2011	-	-
Summer 2012	-	-
Autumn 2012	-	-
4 June 2013	Kl. 15 – 02	11 hours
9 June 2013	Kl. 09 – 11	2 hours
19 June 2013	Kl. 13 – 15	~2 hours
23 June 2013	Kl. 17:30 – 19:30	~2 hours
26 June 2013	Kl. 8 – 9:30	~1.5 hours
30 June 2013	Kl. 15 – 16:20	~1 hour 20 mins.
3 July 2013	Kl. 19:20 – 20:25	~1 hour 5 mins.
12 August 2013		20 hours
3 September 2013	Kl. 21 – 05:00	8 hours
17 June 2014	Late evening	20 hours

Monitoring: Observed by NVE. Front position measurements from 1998. Pictures taken in 1998, 2000-02, 2005-06, 2009. Detailed map surveys in 1978, 1985, 1998 and 2010. GPS measurements of lake level on 5th June and 27th June 2013. Water level recorders were placed in the lake in October 2013.

Future risks: Jøkulhlaup until the glacier retreats so much that the lake is no longer glacier-dammed. Several buildings in Koppangen village are at risk.

References: Hansen, J.A. framtidinord.no 06.09.2010.

Kjøllmoen, B., L.M. Andreassen, H. Elvehøy, M. Jackson and R.H. Giesen. 2011. Glaciological investigations in Norway in 2010. *NVE-report no 3*, 2011.

NVE glacier database, Norge digitalt, www.norgebilder.no.

Krokebreen

Location: Stryn, Sogn & Fjordane.
Latitude: 61.77° N, Longitude: 6.76° E

WGI-ID: N4A000BS018

NVE-Atlas-ID: 2251

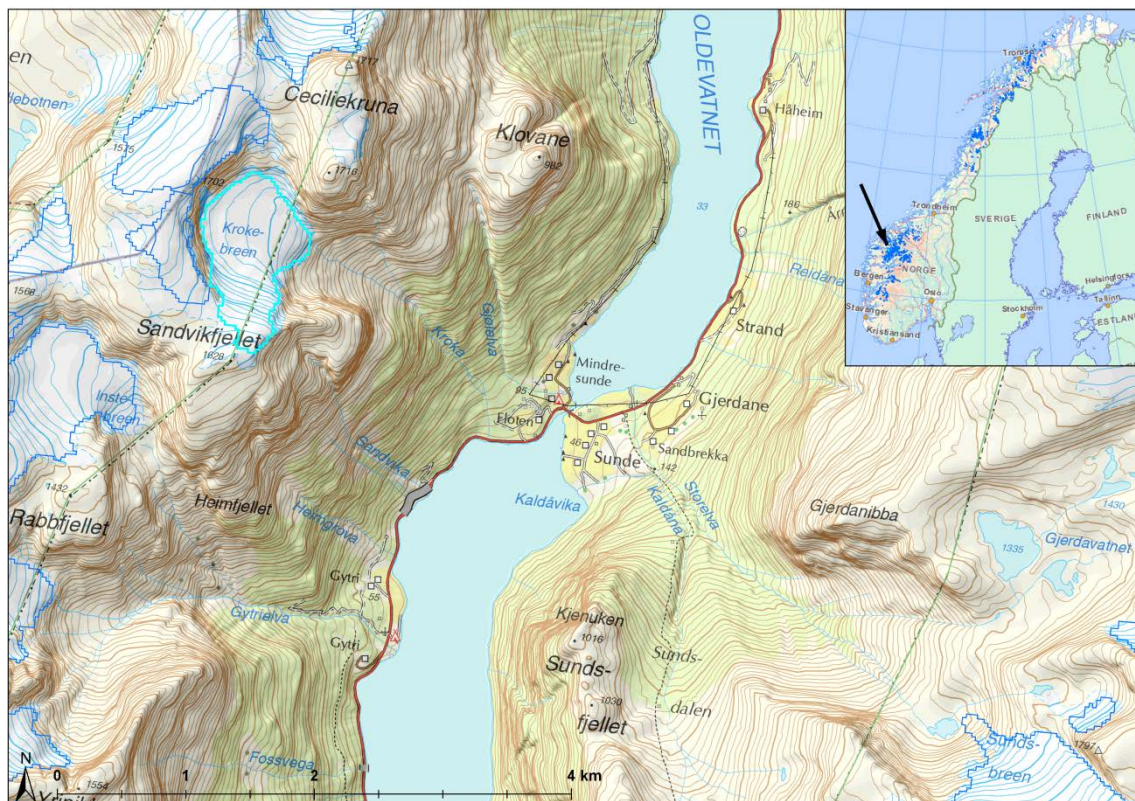
Dimensions: Area: 0.7 km², length: 1.6 km

Altitudinal range: 1168 – 1612 m a.s.l.

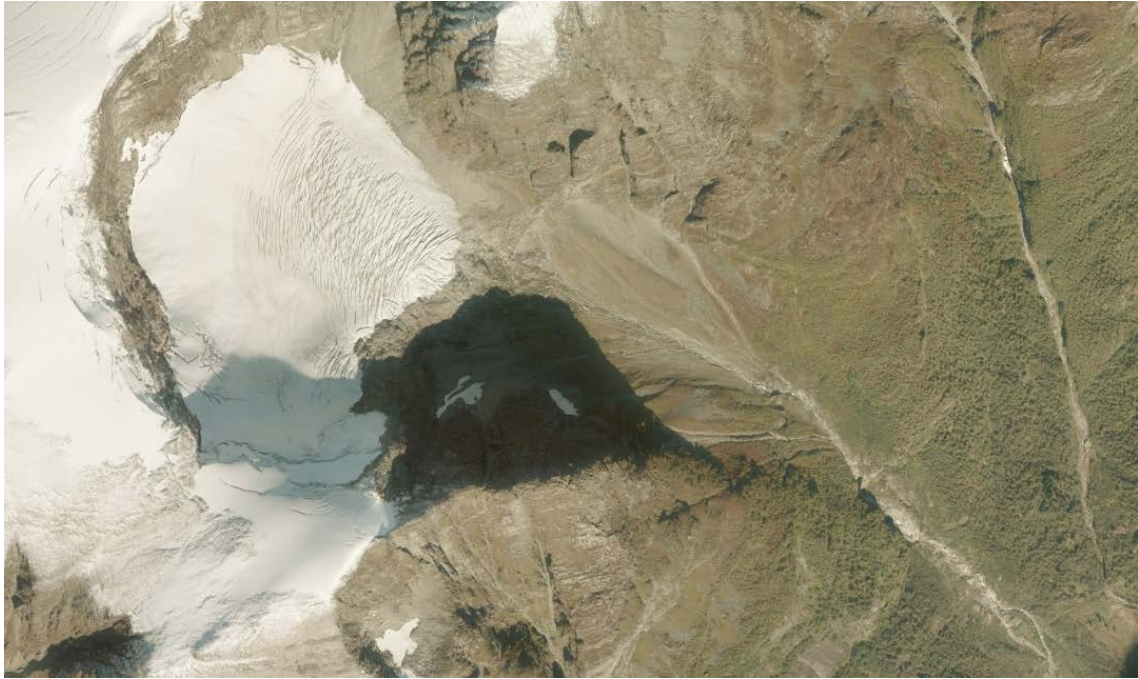
Glacier type: Mountain glacier

Event type: Glacier length change, Ice avalanche

Description: A mountain glacier situated between Sandvikfjellet and Ceciliekruna mountains. It drains to Oldevatnet lake through Kroka river. During the Little Ice Age Krokebreen was an outlet glacier from Myklebustbreen ice cap (Snønipébreen in Eide (1955)), which was then connected to Jostedalsbreen ice cap (Eide, 1955). Below the glacier and by Oldevatnet lies the town of Floten, hence the glacier was called Flåtenbreen by Eide (1955).



Map: Norge digitalt



www.norgeibilder.no (07.09.2010)

Events:

18th century – Glacier length change (advance) which caused extensive damage to farms in Oldedalen valley (Eide, 1955).

Beginning of 20th century – Ice avalanche which went all the way to Oldevatnet lake (Eide, 1955).

Monitoring: –

Future risks: No risk at present because of significant glacier retreat.

References: Eide, T.O., 1955. Breden og bygda. *Noreg Tidsskrift for folkelivsgransking*, Vol. 5, pp. 1–40.

NVE glacier database, Norge digitalt, www.norgeibilder.no.

Leirbrean

Location: Lom, Oppland.
Latitude: 61.56° N, Longitude: 8.11° E

WGI-ID: N4A000AD047

NVE-Atlas-ID: 2638

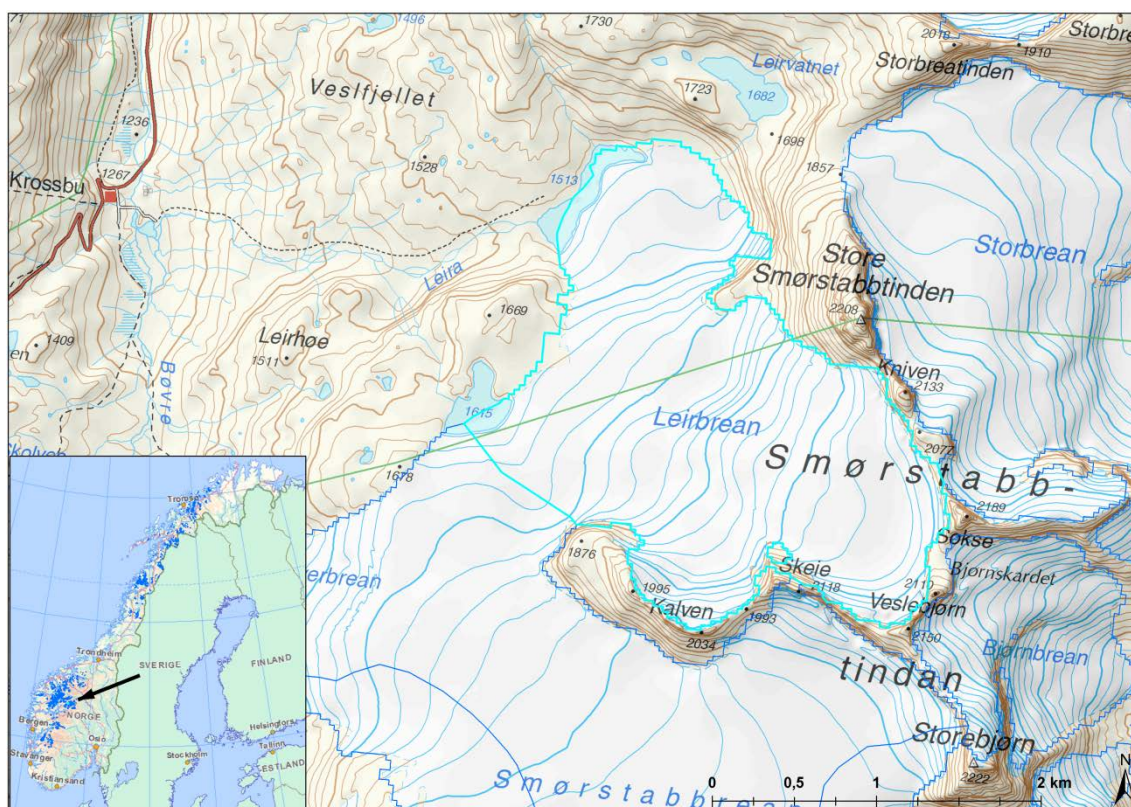
Dimensions: Area: 4.76 km², length: 3.8 km

Altitudinal range: 1513 – 2089 m a.s.l.

Glacier type: Valley glacier

Event type: Mountaineering accident

Description: Leirbrean is a valley glacier, situated in the western part of Jotunheimen just west of Smørstabbtinden. The glacier is connected on its south-west side to Bøverbreen glacier and lies about 2-3 km west of Storbreen glacier. The glacier drains down to Leira river, which meets Bøvre river further downstream at Krossbu.



Map: Norge digitalt



Leirbreen and point NP75 photographed on 9th September 2003. Photo: Miriam Jackson, NVE

Events:

16/08/1998 – Mountaineering accident. Man (53) in a group of 15 people. Accident happened while climbing Store Smørstabbtind, on wet slippery rock without using rope. He slid and fell 15 m down on snow after misjudging conditions. Bruised and shocked.

Monitoring: Photographs, observations and front position measurements (since 1909).

Future risks: The usual risks apply for glacier walking and mountain climbing.

References: Norges Klatreforbund.
NVE glacier database, Norge digitalt.

Lille Brekketind glacier

(This name is unofficial and refers to the location of the glacier close to the mountain ridge of Lille Brekketind)

Location: Sykkylven, Møre & Romsdal.
Latitude: 62.23° N, Longitude: 6.7° E

WGI-ID: N4A000BY009

NVE-Atlas-ID: 1993

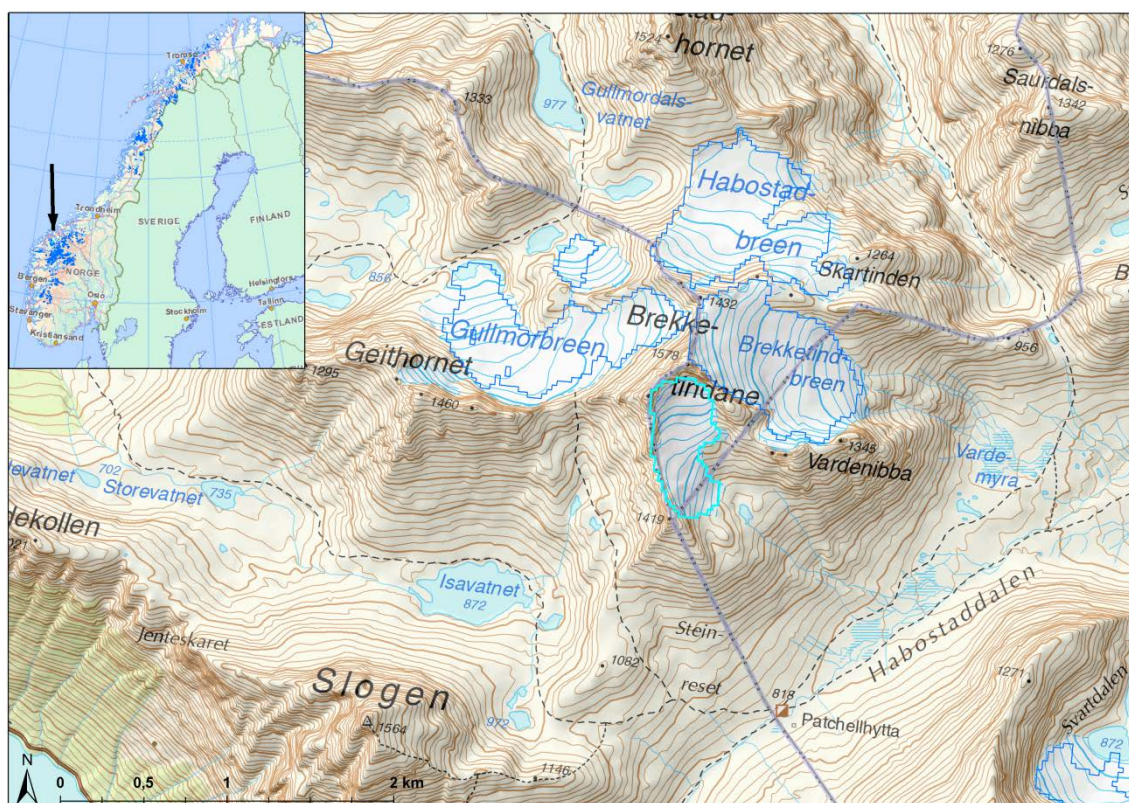
Dimensions: Area: 0.26 km², length: 0.9 km

Altitudinal range: 1192 – 1515 m a.s.l.

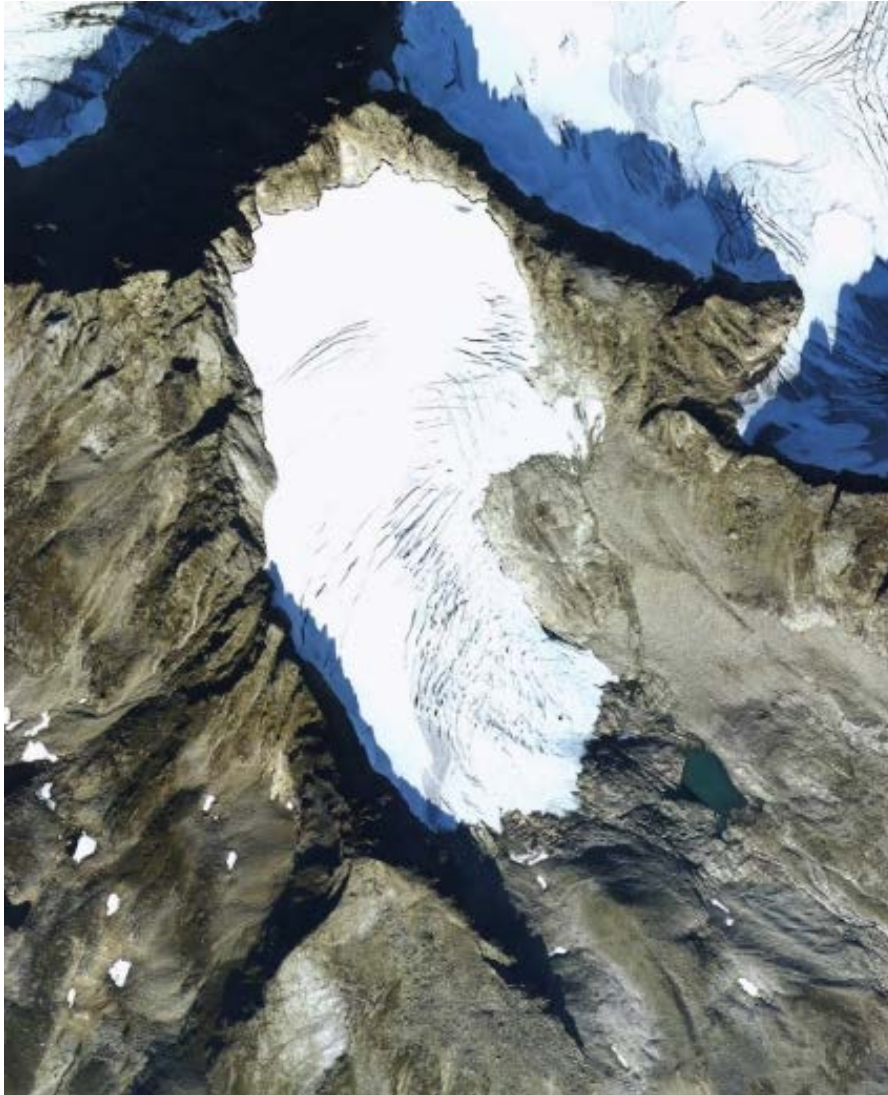
Glacier type: Valley glacier

Event type: Mountaineering accident

Description: Unnamed valley glacier situated on the eastern side of the mountain ridge Lille Brekketind (1419 m a.s.l.) with Gullmorbreen glacier to the north-west and Brekketindbreen glacier to the north-east. Lille Brekketind glacier drains to Habostaddalen valley. There is a tourist cabin, Patchelhytta, situated about 1.4 km from the glacier at the end of Habostaddalen valley.



Map: Norge digitalt



www.norgebilder.no
(15.09.2006)

Events:

2-7/07/1934 – Mountaineering accident. 29 year old Arne Olsen (from Lysaker) disappeared after leaving his backpack in the cabin. An expedition of 16 people from the village of Øye (about 4 km south-west from the cabin) set out to look for him. They found a foot path at Lille Brekketind mountain ridge and close to a crevasse on the glacier. There was a piece of rope of the same type as left in the cabin, found by the path (Aftenposten 16/07/1934).

Monitoring: –

Future risks: The usual risks apply for glacier walking and mountain climbing.

References: Aftenposten 16/07/1934.
NVE glacier database, Norge digitalt.

Lodalsbreen

Location: Luster, Sogn & Fjordane.
Latitude: 61.78° N, Longitude: 7.19° E

WGI-ID: N4A000A4019

NVE-Atlas-ID: 2266

Dimensions: Area: 9.32 km², length: 7.0 km

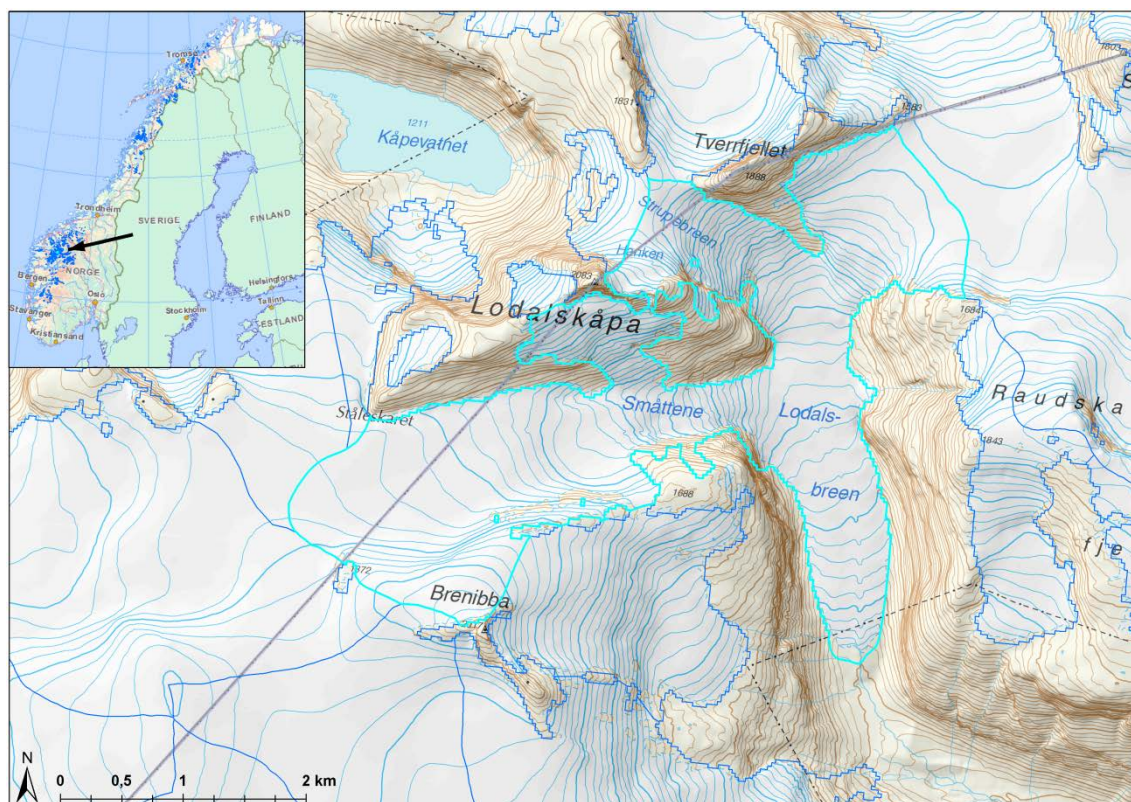
Altitudinal range: 855 – 2004 m a.s.l.

Glacier type: Outlet glacier

Event type: Mountaineering accident

Description: One of the north-eastern outlets from Jostedalbreen ice cap, situated between Bødalsbreen glacier to the west and Erdalsbreen glacier to the east. Lodalsbreen has several glacier streams merging together in the upper part of Stordalen valley. Historically different parts of the glacier have separate names: the glacier part south-east of Lodalskåpa mountain is called Småttene (Smottene), north-east of Lodalskåpa mountain – Hanken and south-west of Tverrfjellet mountain – Strupebreen.

Lodalsbreen was an old glacier pass from the towns and villages of Stryn and Loen municipalities (inner Nordfjord) to Jostedalen valley (<http://snl.no/Lodalsbreen>).



Map: Norge digitalt



Photos by Hallgeir Elvehøy, NVE: **a** – Småttene 16.08.2012, **b** – Lodalsbreen tongue 19.08.2008

Events:

24/04/1969 – Mountaineering accident. Christian Nilsen, one of a group of three NVE-employees performing glaciological fieldwork in the area, fell into a 65 m deep crevasse on a ski trip on Småttene. Christian landed on a 2-3 m wide ice bridge in the crevasse, suffered severe face injuries and lost consciousness. He tried unsuccessfully to rescue himself, found a sleeping bag in his backpack and crept into it. After 9 hours in the crevasse Christian was rescued by helicopter and his friends (Nesdal, 1991). However it was not possible to get his backpack up and Christian had to leave it in the crevasse. It melted out many years later and was on display at the Breheim Centre in Jostedal, until the museum burnt down in 2011 together with its exhibits.

Monitoring: Photos taken in 1899, 1997, 1999, 2000, 2004, 2006, 2007, 2008 and 2012.
Front position measurements 1899-1970

Future risks: Mountaineering – especially skiers on Smottene.

References: Nesdal, S. 1991. Lodalen – Fager og Fårleg. *Tyrmi Trykk AS, Oslo*, 133 p.
Store norske leksikon (2005-2007) <http://snl.no/Lodalsbreen>.
NVE glacier database, Norge digitalt.

Marabreen

Location: Jølster, Sogn & Fjordane.
Latitude: 61.51° N, Longitude: 6.71° E

WGI-ID: –

NVE-Atlas-ID: 2364

Dimensions: Area: 2.53 km², length: 3.4 km

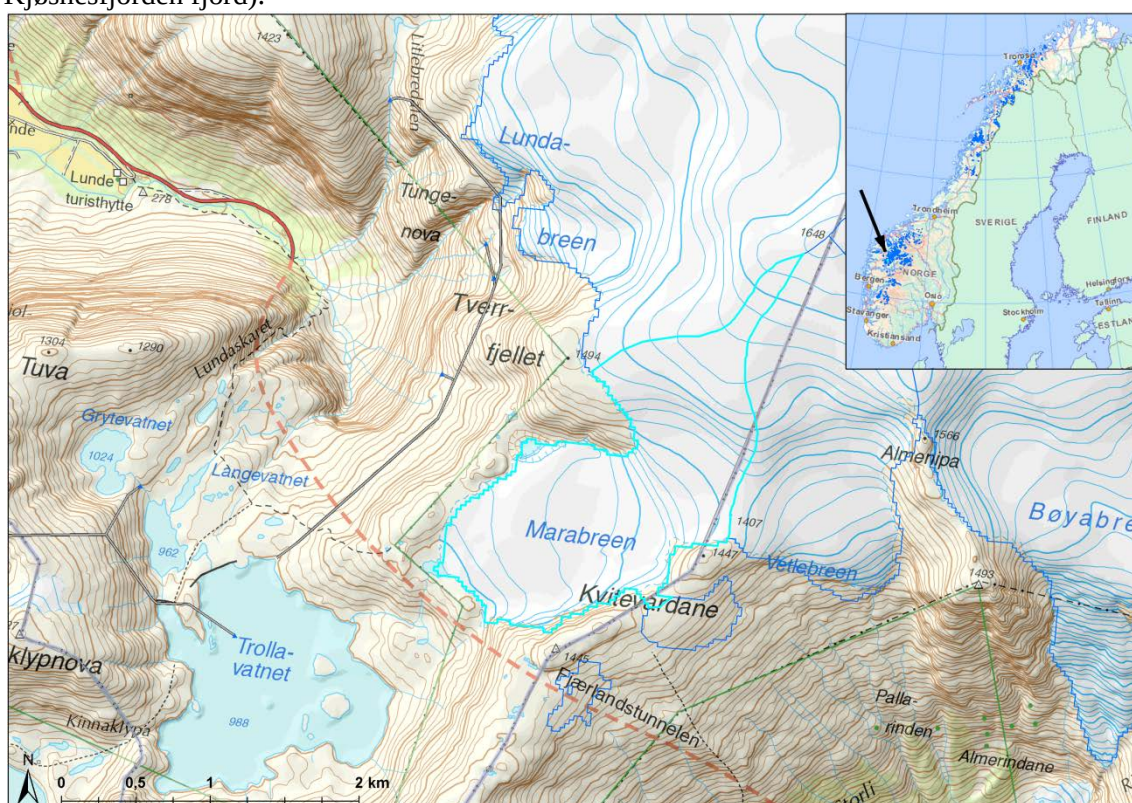
Altitudinal range: 1183 – 1620 m a.s.l.

Glacier type: Outlet glacier

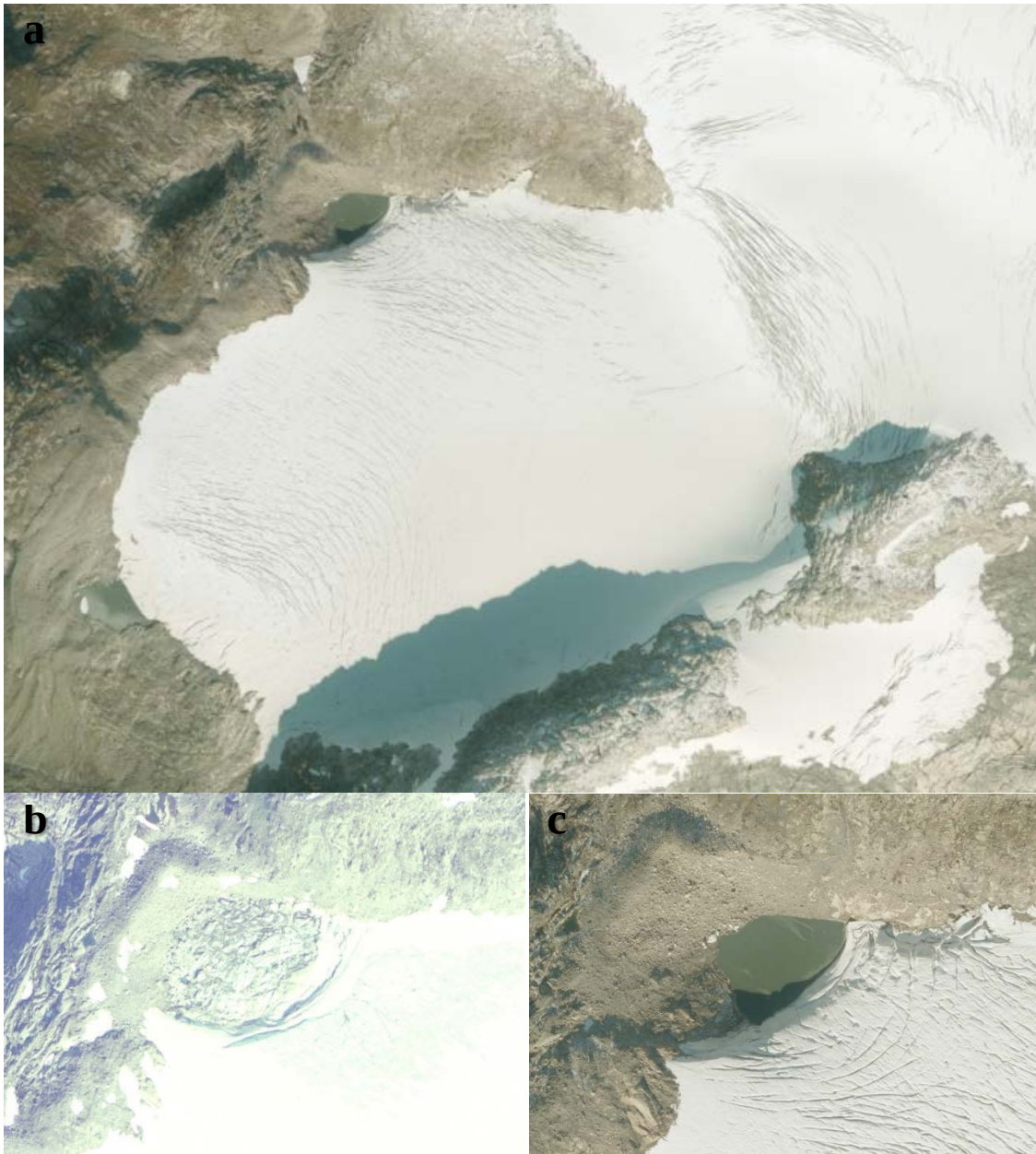
Event type: Jøkulhlaup

Description: South-west outlet from Jostedalsbreen ice cap, situated between Lundabreen glacier to the north-west and Vetlebreen glacier to the east. Marabreen drains to Trollavatnet lake, from which water is partly redirected for hydropower production. On its north-western side, Marabreen dams a lake (estimated size of the full lake is about 30 000 m², which suggests a volume of about 100 000 m³).

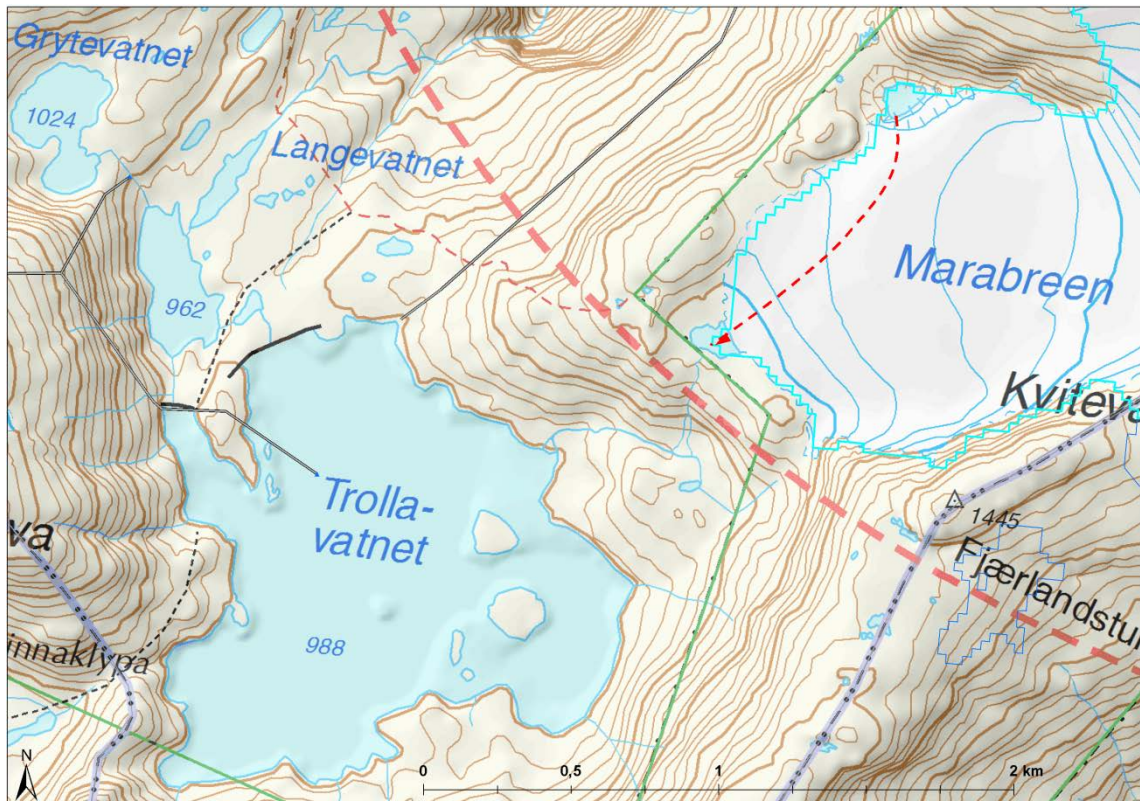
There is a tourist road leading to Marabreen from Lunde tourist cabin (1 km south-east of Kjøsnesfjorden fjord).



Map: Norge digitalt



www.norgebilder.no: **a** – Marabreen and glacier-dammed lake 26.09.2010, **b** – Glacier-dammed lake shortly after jökulhlaup 12.08.2004, **c** – Glacier-dammed lake on 26.09.2010, showing that water was accumulating once more.



Map: Norge digitalt. Probable drainage path of the water is shown in red. Water from a jökulhlaup would ultimately drain to a hydropower reservoir and potential damage is unlikely.

Events:

July-August 2004 – Jökulhlaup. Not observed but estimated from the 2004-norgebilder.no picture.

Monitoring: –

Future risks: Jökulhlaup. The effect would probably be positive since the water is used for hydropower production.

References: NVE glacier database, Norge digitalt, www.norgebilder.no.

Middagstuvebreen

(This name is unofficial and refers to the location of the glacier close to Middagstuva)

Location: Meløy, Nordland.

Latitude: 66.74° N, Longitude: 14.01° E

WGI-ID: N4A000C4001

NVE-Atlas-ID: 1080

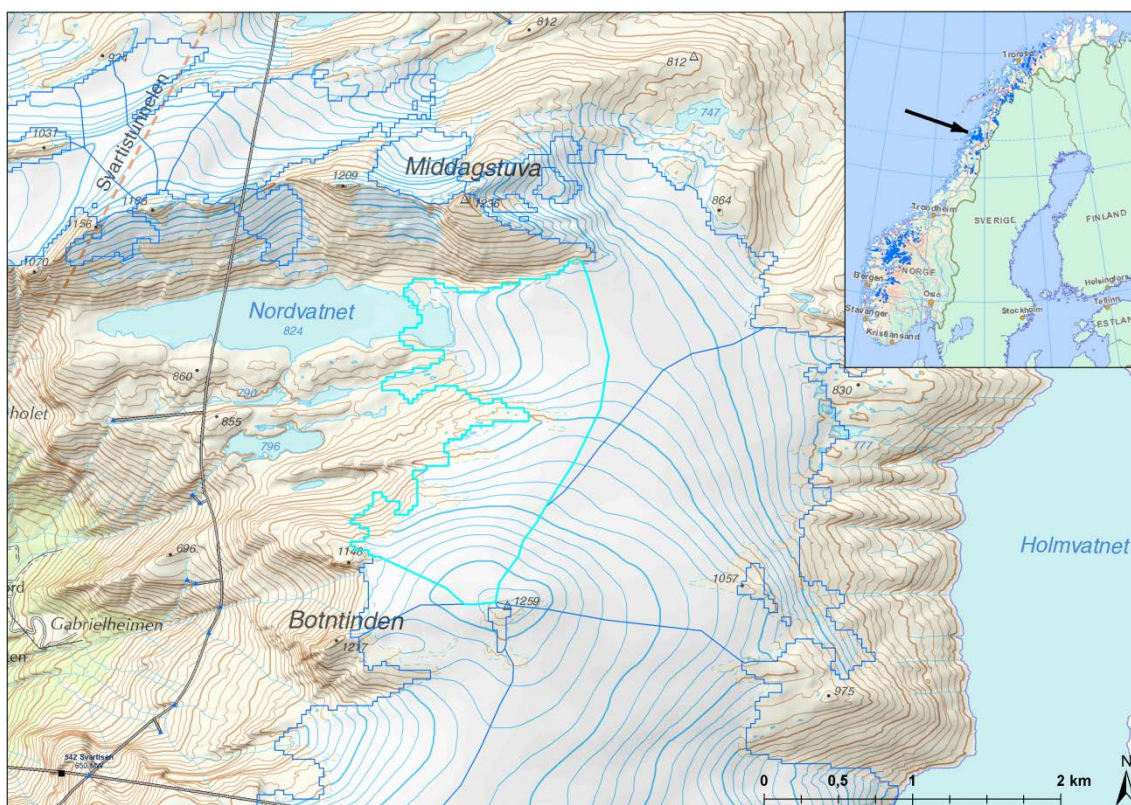
Dimensions: Area: 2.17 km², length: 2 km

Altitudinal range: 823 – 1243 m a.s.l.

Glacier type: Outlet glacier

Event type: Jøkulhlaup

Description: Outlet from Vestre Svartisen icecap. Lake Nordvatnet at 824 m a.s.l. drains from its western end through Bjørnholet to Storjorda i Nordfjorden/Holandsfjorden. The lake was previously filled with glacier ice, and when the glacier melted and the lake grew, the glacier dammed the lake for a limited period.

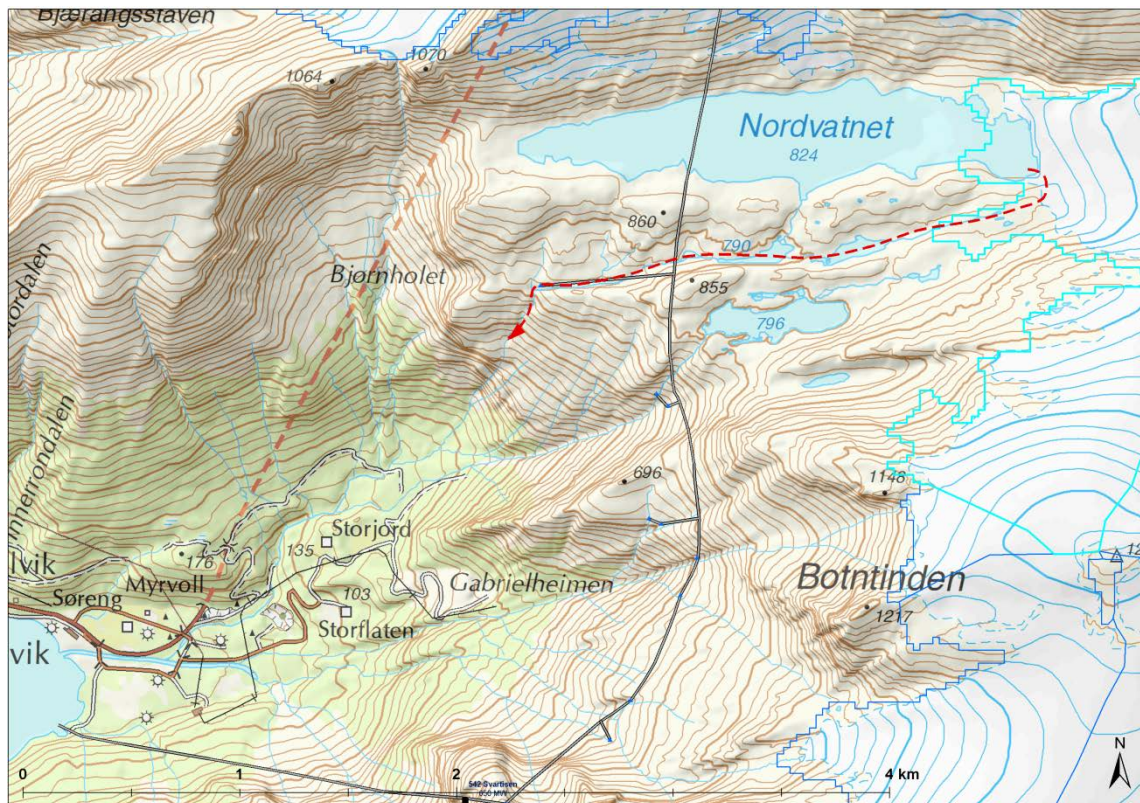


Map: Norge digitalt



a – Middagstuvebreen with Nordvatnet Lake from www.norgebilder.no (24.08.2008);

b – Eastern part of lake Nordvatnet photographed from helicopter on 28th August 2012. Photo: Hallgeir Elvehøy, NVE.



Map: Norge digitalt. Probable drainage path of water from a jøkulhlaup is shown in red. The water would drain to Kilvik and could damage several structures there.

Events:

26/08/1971 – Jøkulhlaup from lake Nordvatnet. Extreme rainfall and glacier melt led to extreme flood.

Monitoring: Observed by NVE (field visit in August 2012).

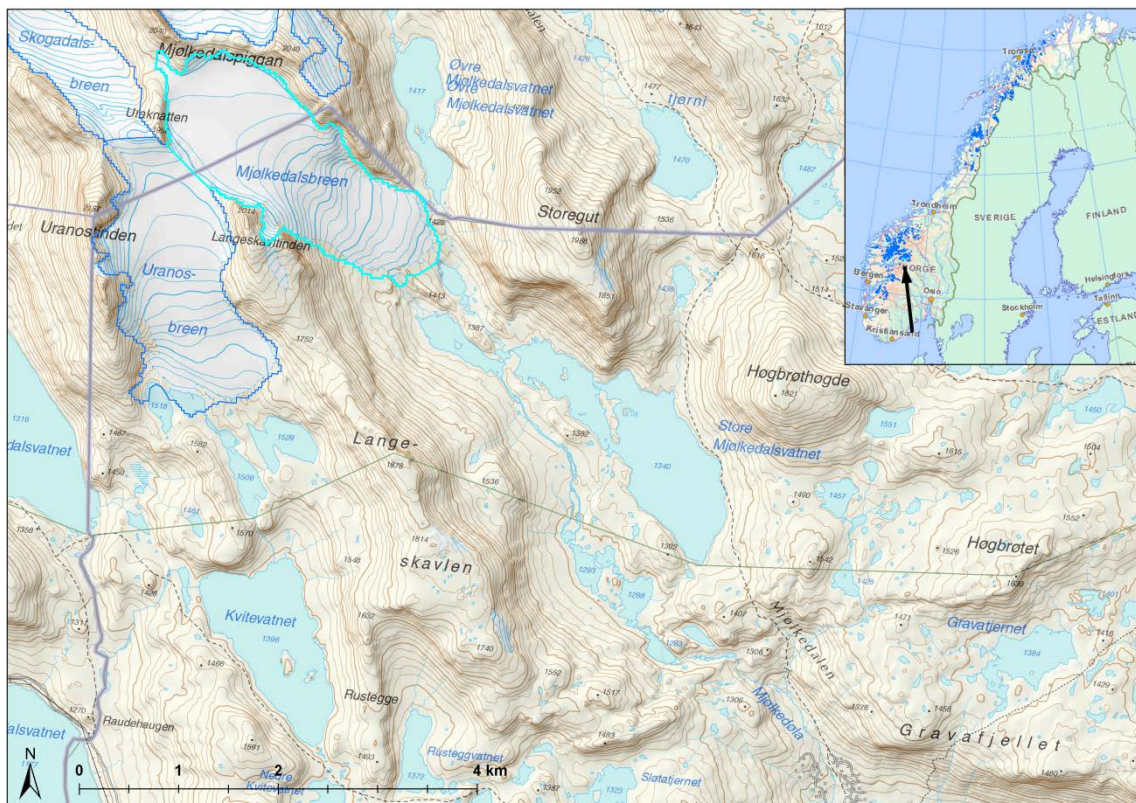
Future risks: Continued glacier retreat may lead to a jøkulhlaup at the eastern end of the lake.

References: NVE glacier database, Norge digitalt, www.norgebilder.no.

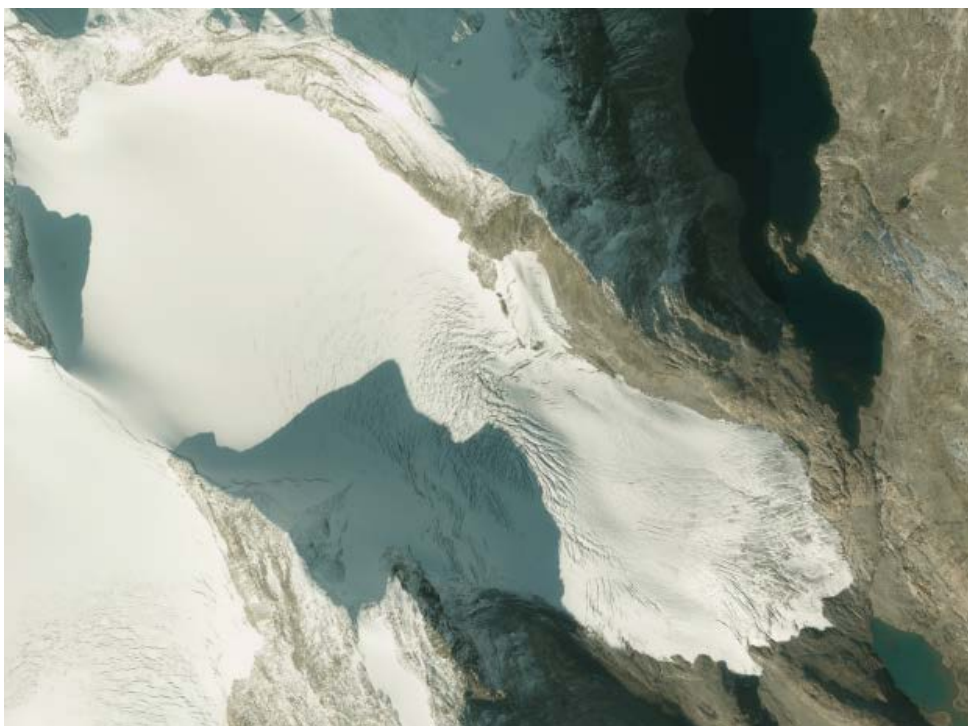
Mjølkedalsbreen

Location:	Vang, Oppland. Latitude: 61.43° N, Longitude: 8.19° E
WGI-ID:	N4A000AA001
NVE-Atlas-ID:	2717
Dimensions:	Area: 3.21 km ² , length: 3.3 km
Altitudinal range:	1384 – 1937 m a.s.l.
Glacier type:	Valley glacier
Event type:	Jøkulhlaup

Description: Southern Jotunheimen, north of Tyin lake. Mjølkedalsbreen flows southeastwards, and lies in the uppermost part of the valley Mjølkedalen. Previously, the glacier was larger (before the middle of 19th century) and dammed Lake Øvre Mjølkedalsvatn. When the lake was full outflow was apparently northwards, over a low pass to Skogadalen valley. Distinct signs of water erosion can be seen in the couloirs facing Skogadalen. When the lake emptied under the glacier, the outflow would pass through lake Store Mjølkedalsvatn to Bygdin.



Map: Norge digitalt



www.norgebilder.no (28.09.2010)

Events:

1855-1937 – Jøkulhlaups. River Vinstra/Mjølkedøla at Mjølkedalen, Oppland. Jøkulhlaup from Øvre Mjølkedalsvatn. Effect: Flood damage.

11/08/1855, 1865, 1875, 1879, 1894, 02/08/1899 – Jøkulhlaups. Volumes are not known. In **1865** the river washed away all loose material over an extensive area. This flood was presumably the most extensive until then.

02/08/1916 – volume: 18 mill m³

13/08/1929 – volume: 12 mill m³

03/08/1921 – volume: 33 mill m³, duration 48 hrs, max water discharge 500 m³/s

14/11/1931 – volume: 19 mill m³

15/07/1932 – volume: 3 mill m³

30/03/1925 – volume: 25 mill m³

04/01/1936 – volume: 26 mill m³

18/08/1927 – volume: 17 mill m³

30/01/1937 – volume: 3 mill m³

Monitoring: Water-level observations in lake Bygdin, into which the river Mjølkedøla flows, have been carried out since 1915.

Future risks: No risk at present due to glacier retreat.

References: Liestøl, O. 1956. Glacier Dammed Lakes in Norway. *Norsk geografisk tidsskrift* nr. 3-4. Bind XV, 1955-1956, h. 3-4.

NVE glacier database, Norge digitalt, www.norgebilder.no.

Myklebustbreen (Ø)

Location: Stryn, Sogn & Fjordane.
Latitude: 61.71° N, Longitude: 6.73° E

WGI-ID: N4A000BS016

NVE-Atlas-ID: 2286

Dimensions: Area: 3.4 km², length: 2.1 km

Altitudinal range: 1071 – 1728 m a.s.l.

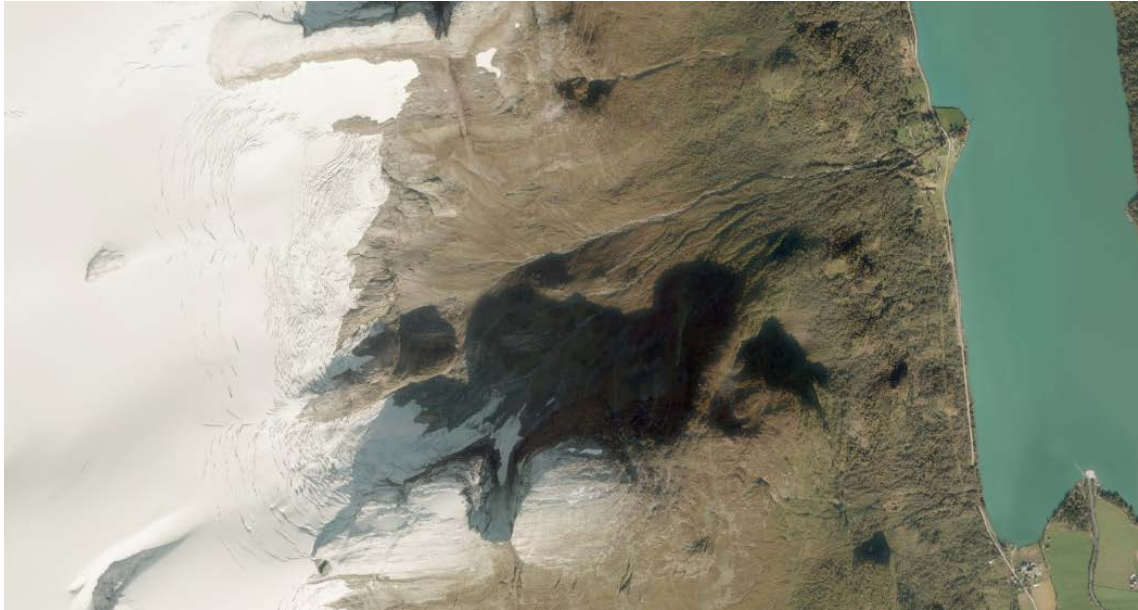
Glacier type: Outlet glacier

Event type: Glacier length change, Ice avalanche

Description: One of the unnamed eastern outlets from Myklebustbreen icecap, situated to the north of Instebreen glacier, between Yrinibba mountain summit and Rustøyfjellet mountain. The glacier drains to Yrielve river which flows into lake of Oldevatnet Sør by the villages of Yri and Bak-Yri.



Map: Norge digitalt



www.norgebilder.no (07.09.2010)

Events:

1687 – Glacier length change, ice avalanches. The taxes of the farm of Yri were reduced on account of landslides and glacier encroachment (Aaland, 1932).

1693 – Glacier length change, ice avalanches. ‘The farm Indre-Yri has time and again been caused even more damage, always by the same means, and in particular, winter 1692-93 when a glacier (Blaabræde) lying above the farm and its adjacent lands gradually comes further and further down and finally falls and causes damage, bringing with it a great mass of rocks, grit and sand from the mountain which has taken away almost all the arable land here and partly covering and ruining it’.

‘At the farm of Bak-Yri the glacier and landslides did not only cover and ruin the farm’s arable land with gravel and rocks, but also carried away two mill houses with their equipment and destroyed the mills, a smithy and two boathouses by lake Sør Oldevatnet’ (Grove, 1988).

Monitoring: –

Future risk: The ice avalanches were associated with glacier advance during the Little Ice Age. There is no risk under the present conditions.

References: Aaland, J. 1932. *Nordfjord fra gamle dagar til no. Dei einskilde bygder: Innvik – Stryn – Sandane*. Vol. 2, Oslo, Eli Nemnd.

Grove, J.M. 1988. *The Little Ice Age*. Methuen, London and New York, pp. 64-107.

NVE glacier database, Norge digitalt, www.norgebilder.no.

Nigardsbreen

Location:	Luster, Sogn & Fjordane. Latitude: 61.72° N, Longitude: 7.1° E
WGI-ID:	N4A000A4014
NVE-Atlas-ID:	2297
Dimensions:	Area: 42.02 km ² , length: 10.8 km
Altitudinal range:	345 – 1946 m a.s.l.
Glacier type:	Outlet valley glacier
Event type:	Ice avalanche, Mountaineering accident, Glacier length change

Description: Nigardsbreen is an eastern outlet glacier from Jostedalsglaciären icecap – the largest glacier on the European mainland. It is one of Norway's most visited glaciers, with easy access, and guided tours on the glacier and to the front every day in summer. The glacier advanced significantly during the late 1980s-1990s and the front of the glacier became rather steep. The glacier front was unstable and small ice falls as well water tunnel collapses (which can lead to a sudden flood) occurred on a regular basis. However, the glacier has retreated 169 m between autumn 2000 and autumn 2012, and the glacier front is now much flatter and more stable.



Map: Norge digitalt



The glacier tongue immediately before the accident and the following day. Photos: Heike Uthmann; Jo Hjelle

Events:

1710 – 1735 – Glacier length changes (advance). The front of Nigardsbreen advanced about 2800m (Grove, 1988).

Summer 1741 – Glacier length changes (advance). Significant damage to the farms Mjelver, Elvekrok, Berseter (probably Bergset in Krundalen) and other farms (Eide, 1955).

1742 – Glacier length changes (advance). Six fields near the head of Mjølverdalen were covered by ice (Grove, 1988).

August 1743 – Glacier length changes (advance). The farm Nigard was totally destroyed. The glacier damaged fields and meadows of Bjørkehaugen farm, and the farm buildings were uninhabitable (Foss, 1750).

14/08/1979 – River Jostedøla; extreme flood after intense rainfall and glacier melt. 32 mill NOK worth of damage. The event was not a jøkulhlaup, but the severe rainfall intensified snow melting thus magnifying the flood.

22/07/1986 – Glacier length changes / Ice avalanche. The end of the water-tunnel at the glacier front collapsed, and dammed the river. When the dam broke, a huge volume of water and

ice-blocks was released. 12 people were caught by the water and ice, and 2 of them died (Finnmark dagblad 23/07/1986).

12/08/1994 – Glacier length change / Ice avalanche / Calving. Blocks of ice from the glacier front broke off and a Polish woman was seriously hurt when she was hit by the ice-blocks and thrown into the water. Three people injured (Stavanger Aftenblad 13/08/1994).

14/10/1995 – Mountaineering accident. A man died from his injuries after falling into a crevasse (Aftenposten 15/10/1995).

01/08/1998 – Mountaineering accident. Male (24) tripped in crampons, slid 5-6 m and fell into a crevasse; broken leg, fractured foot. He was part of a group participating in a glacier course, was unsecured and had little experience (Norges Klatreforbund).

16/08/2001 – Ice avalanche. Ice and rock avalanches due to heavy rain.

02/06/2011 – Mountaineering accident. A group of three teenagers were about to exit the glacier at a flat area. One of them stuck his crampon into the ice the wrong way, lost his footing, slid 8-9 m and fell into a 4 m deep crevasse. He broke his left ankle and damaged his ligaments. He was first rescued by his comrades, then evacuated by helicopter (Norges Klatreforbund).

10/08/2014 – Ice avalanche. Two German tourists were killed when ice at the glacier front collapsed and fell onto them (Bergen Tidene 11/08/2014).

Monitoring: Mass balance measurements by NVE from 1962
Front position measurements from 1899
Glacier velocity, velocity change, aerial/satellite photos
DEM
Subglacial and surface topography
Radar measurements and ice thickness
Detailed map surveys in 1964, 1974, 1984 and 2009

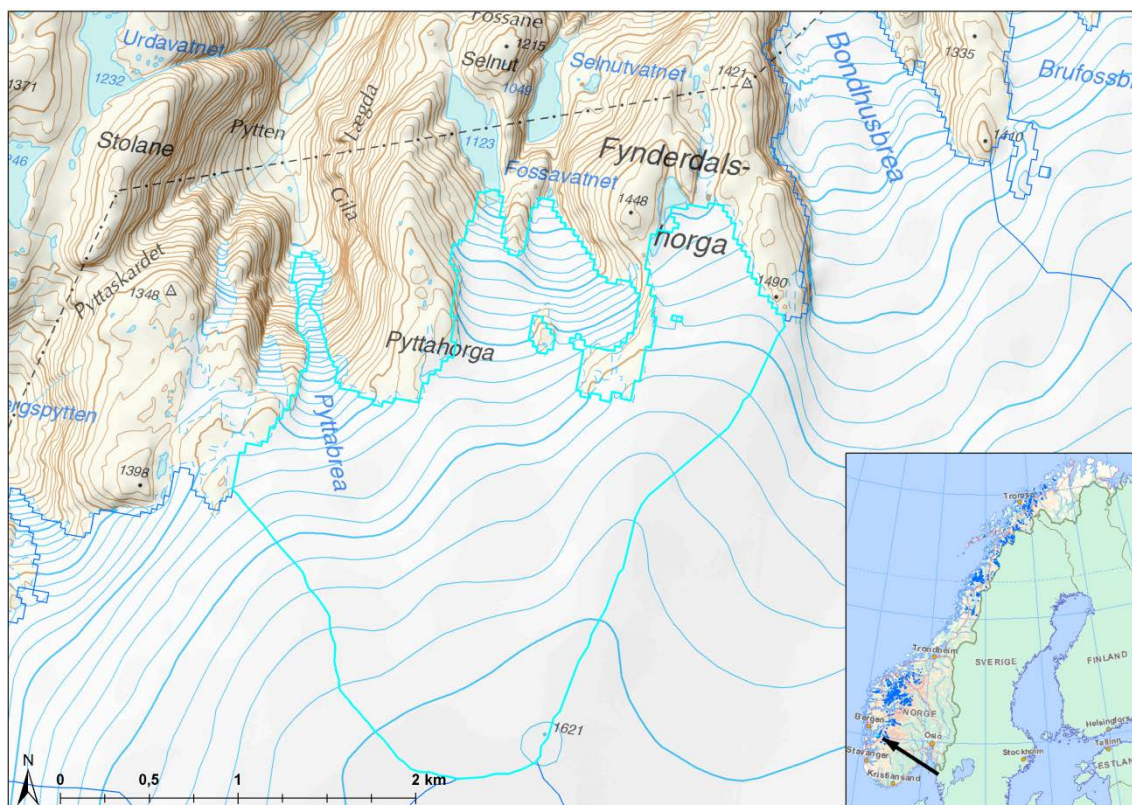
Future risk: Effects from glacier length changes
Ice avalanche from the sides and front of the glacier, collapse of ice tunnels.
The tongue is retreating, which means less ice avalanching at the snout and sides.

References: Aftenposten 15/10/1995, Finnmark dagblad 23/07/1986, Stavanger Aftenblad 13/08/1994, Bergen Tidene 11/08/2014.
Eide, T.O., 1955. Breden og bygda. *Noreg Tidsskrift for folkelivsgransking*, Vol. 5, pp. 1-40.
Grove, J.M. 1988. The Little Ice Age. *Methuen, London and New York*, pp. 64-107.
Foss, M. 1750. In Berge, J.C. (ed., 1802-3) *Justedalens kortelige Beskrivelse*. Norges Klatreforbund.
NVE glacier database, Norge digitalt.

Pyttabrea

Location:	Kvinnherad, Hordaland. Latitude: 60.03° N, Longitude: 6.28° E
WGI-ID:	N4A000AJ007
NVE-Atlas-ID:	3132
Dimensions:	Area: 5.32 km ² , length: 3.4 km
Altitudinal range:	815 – 1621 m a.s.l.
Glacier type:	Outlet glacier
Event type:	Potential jøkulhlaup

Description: Pyttabrea is an outlet glacier from Søndre Folgefonna ice cap. It is situated to the west of Bondhusbrea glacier and has three glacier tongues. Pyttabrea drains northwards to Pyttelva river in Fynderdalen valley and thence to Bondhusvatnet lake (189 m a.s.l.).

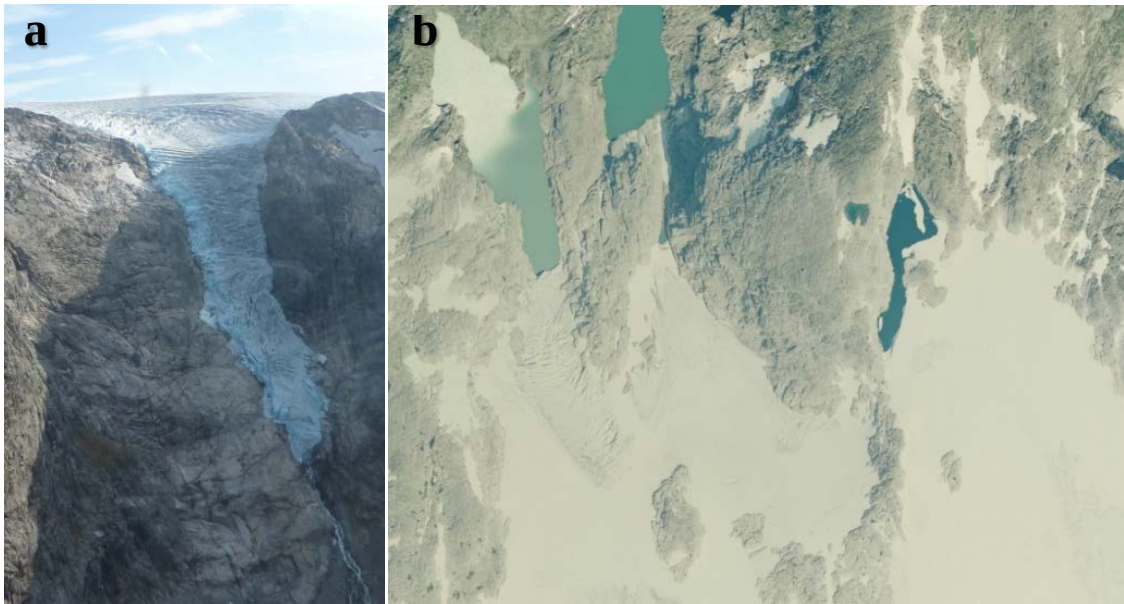


Map: Norge digitalt

On the western side of the eastern tongue of Pyttabrea (east of Fynderdalshorga mountain summit) there is an unnamed glacier-dammed lake. The estimated area of the lake is about 0.03 km² (2006).

Monitoring: Monitored by NVE. Pictures taken in 1997 and 2011.

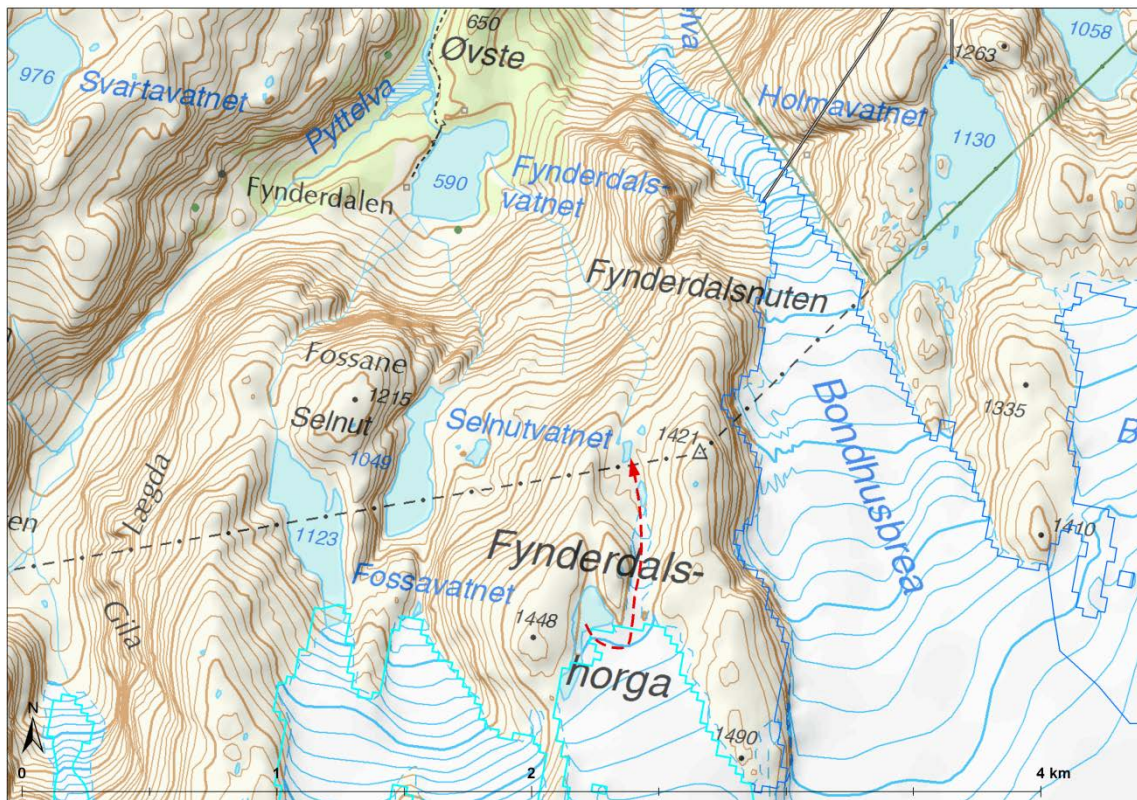
Future risks: Jøkulhlaup.



a – Western tongue of Pyttabrea photographed on 1st October 2011 by Hallgeir Elvehøy, NVE;

b – Pyttabrea from www.norgebilder.no (16.07.2006)

Probable drainage path from a jøkulhlaup is shown in red. The water would drain to Fynderdalsvatnet and could cause this to overflow and cause damage to agricultural land along Pyttelva.



Map: Norge digitalt

References: NVE glacier database, Norge digitalt, www.norgebilder.no.

Ramnefjellbreen (W)

Location: Stryn, Sogn & Fjordane.
Latitude: 61.8° N, Longitude: 6.89° E

WGI-ID: N4A000BS002

NVE-Atlas-ID: 2239

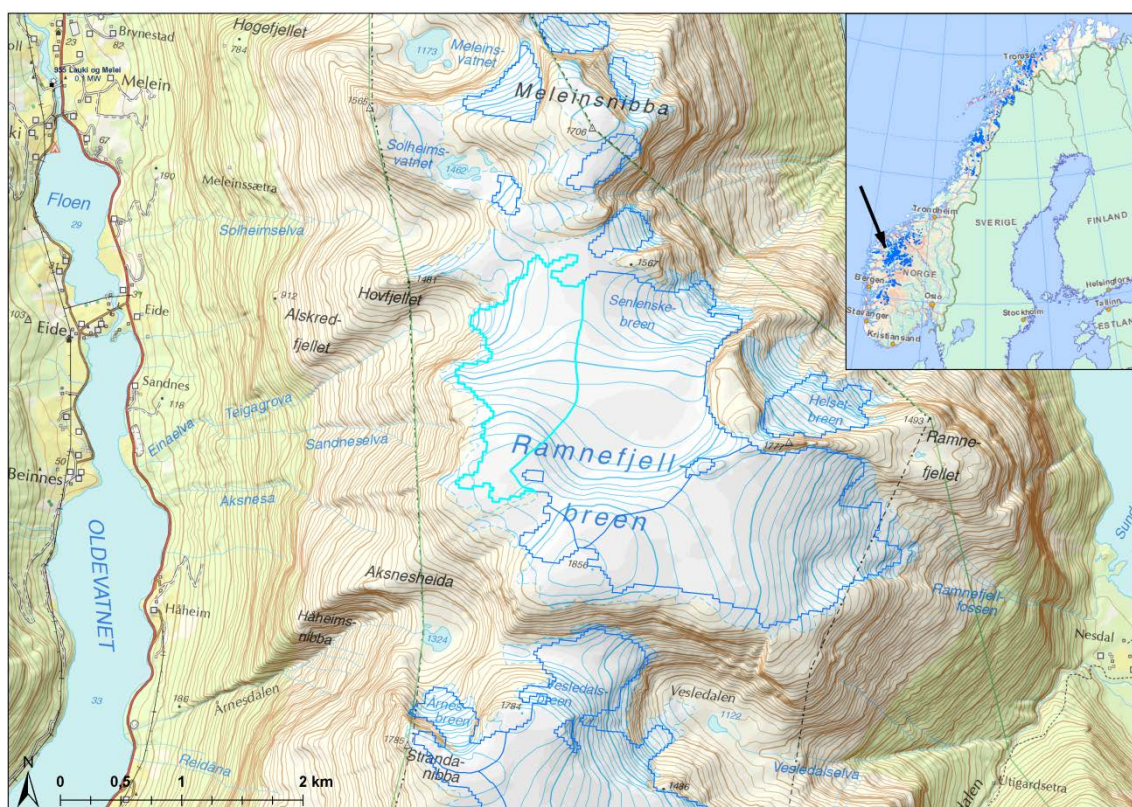
Dimensions: Area: 1.22 km², length: 1.9 km

Altitudinal range: 1396 – 1783 m a.s.l.

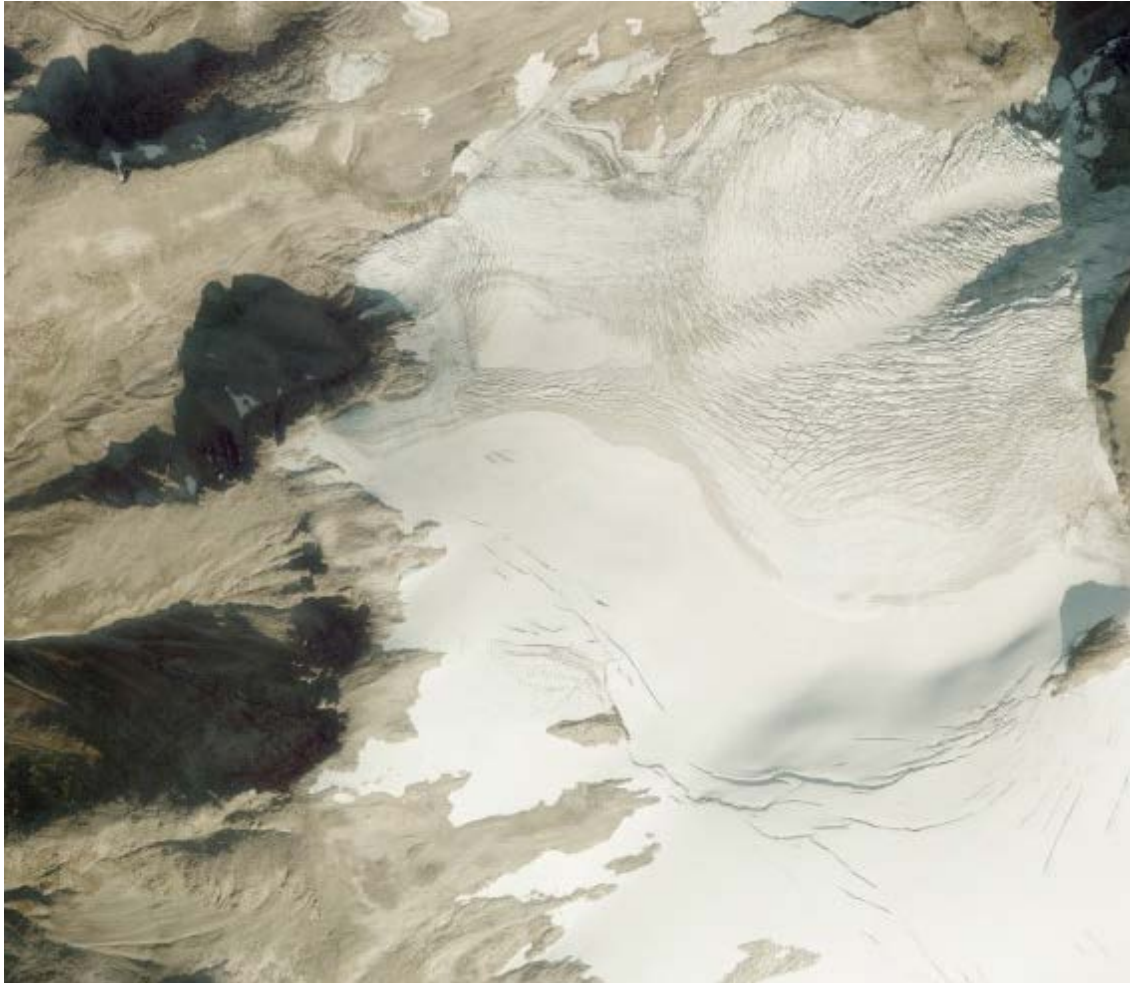
Glacier type: Outlet glacier

Event type: Glacier length change

Description: A western outlet of Ramnefjellbreen ice cap without an individual name, situated west of Senlenskebreen glacier. It drains to Oldevatnet lake. During the Little Ice Age the glacier probably also covered areas around Meleinsnibba mountain summit.



Map: Norge digitalt



www.norgeibilder.no (07.09.2010)

Events:

End of 17th – beginning of 18th century – Glacier length change (advance) which caused floods and landslides in the area. The farms of Håheim, Sandnes and Brynestad in Olden were damaged (Eide, 1955).

Monitoring: –

Future risks: No future risk unless the glacier grew substantially.

References: Eide, T.O., 1955. Breden og bygda. *Noreg Tidsskrift for folkelivsgransking*, Vol. 5, pp. 1-40.

NVE glacier database, Norge digitalt, www.norgeibilder.no.

Reinvikisen

Location: Sørfold, Nordland.
Latitude: 67.71° N, Longitude: 15.64° E

WGI-ID: N4A000DM002

NVE-Atlas-ID: 865 and 868

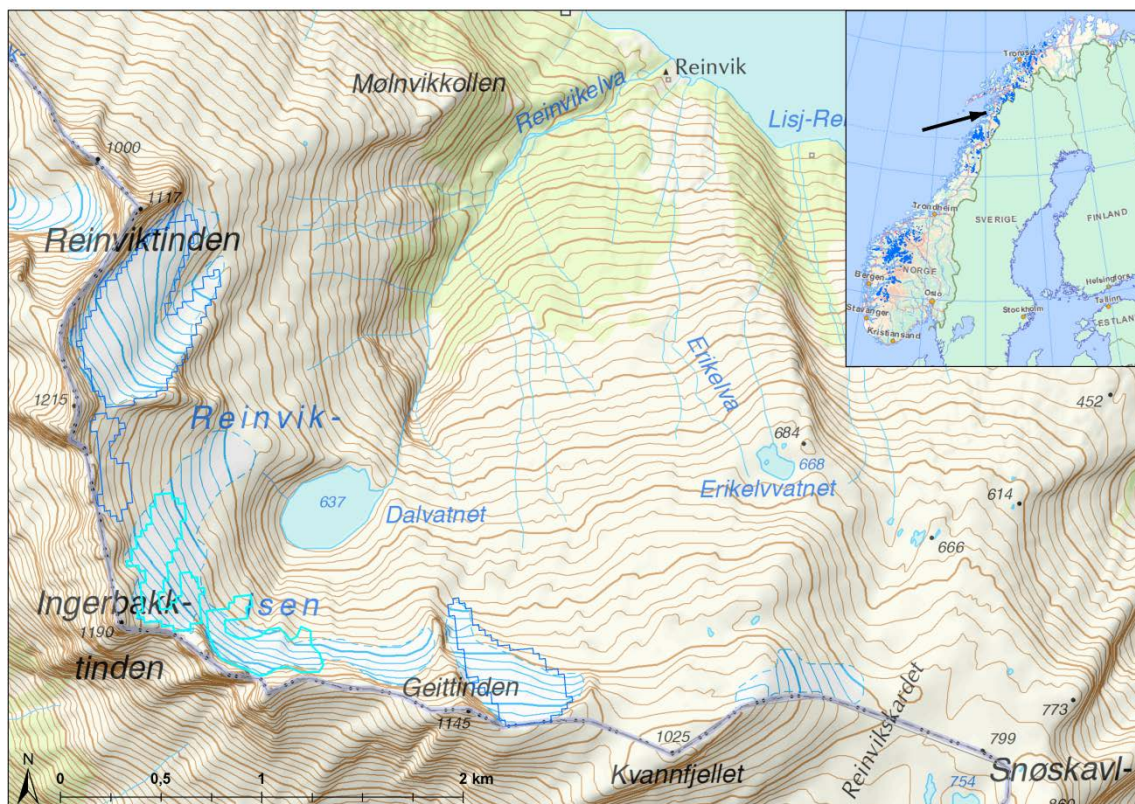
Dimensions: Area: 0.24 km², length: 0.6 km

Altitudinal range: 848 – 1099 m a.s.l.

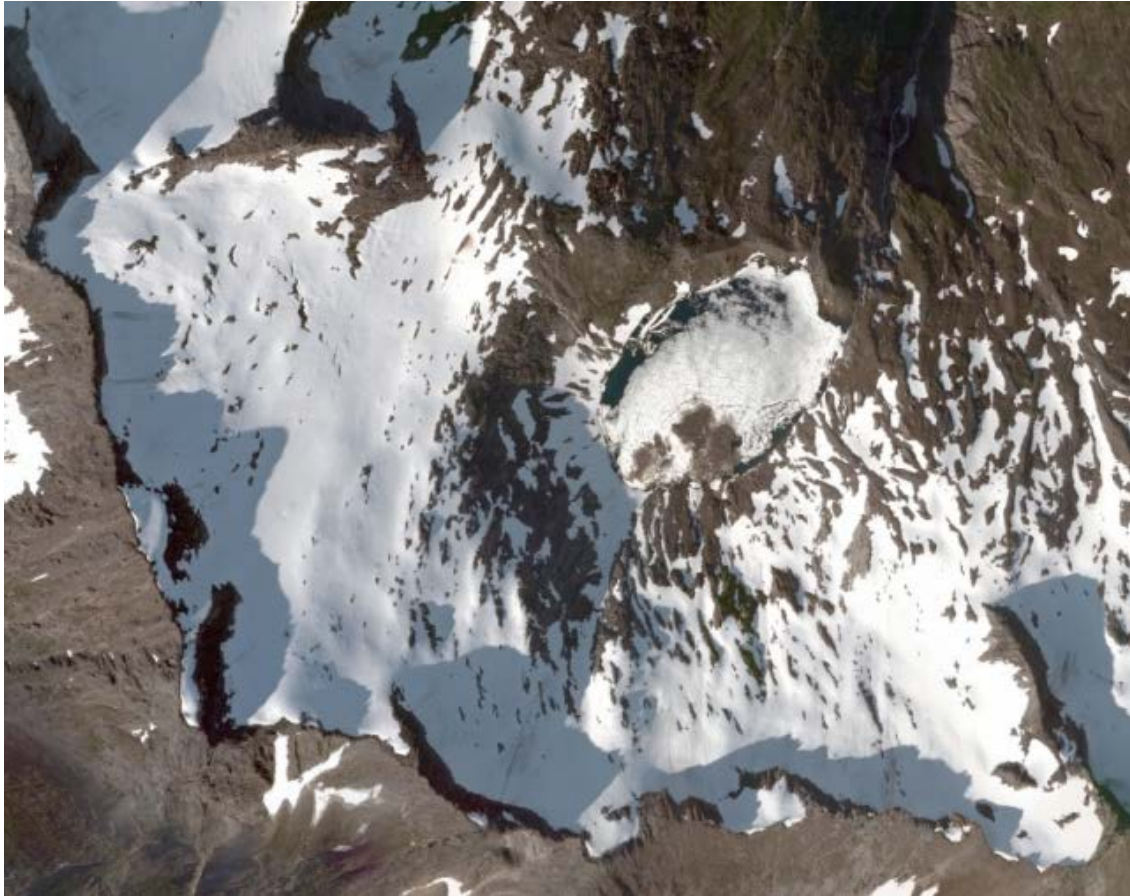
Glacier type: Cirque glacier

Event type: Ice avalanche

Description: At present Reinvikisen is separated into two tiny cirque glaciers, situated on the eastern side of Ingerbakk-tinden glacier horn, on Stábánjárgga peninsula. The glaciers drain to Dalvatnet lake and further to Reinvikelva river, which eventually drains into Mørsvikfjorden fjord near the small village of Reinvik.



Map: Norge digitalt



www.norgebilder.no (17.09.2009)

Events:

20/03/1966 – Ice avalanche (causing flood). Part of Reinvikisen detached and fell into Dalvatnet lake. The ice, being 1.5 m thick, was broken up and a flood wave of water and ice gushed out of the lake and down the fjord sides, sweeping along snow, earth and large boulders. At the fjord the slide was 300 m wide, covering the fields with gravel up to a thickness of a couple of metres. All buildings of one farm were destroyed and another farm suffered damage (Jørstad, 1968).

Monitoring: –

Future risks: The glacier is much smaller at present than it was in 1966, and thus the risk is greatly decreased. However anything falling into the lake, whether rockfall, snow avalanche or icefall, may generate a similar event.

References: Jørstad, F.A. 1968. Waves generated by landslides in Norwegian fjords and lakes. *Norwegian Geotechnical Institute*, publ. nr. 79, pp. 13–32.

NVE glacier database, Norge digitalt, www.norgebilder.no.

Rembesdalskåka

Location:	Eidfjord, Hordaland. Latitude: 60.54° N, Longitude: 7.41° E
WGI-ID:	N4A000AO001
NVE-Atlas-ID:	2968
Dimensions:	Area: 17.44 km ² , length: 9.1 km
Altitudinal range:	1038 – 1860 m a.s.l.
Glacier type:	Outlet glacier
Event type:	Jøkulhlaup, Mountaineering accident

Description: Western outlet from Hardangerjøkulen icecap. Rembesdalskåka dams lake Demmevatn, and drains into the populated valley Simadalen. There are observations of jøkulhlaups in this valley from before 1800. Catastrophic floods in 1893 and 1937 led to the construction of several drainage tunnels. The tunnel completed in 1899 lowered lake level by approximately 20 m, one completed in 1938 lowered it an additional 50 m and there was also a diversion tunnel constructed in the 1970s for hydropower purposes. Extensive thinning of the lowermost part of the glacier led to a flood in summer 2014, the first since 1938.

Maximum discharge and total volume of a jøkulhlaup depend on water level and on glacier thickness adjacent to Demmevatnet. A previous report suggested that if a tunnels is blocked, then a flood of 10 million m³ or more could occur. However, based on present glacier geometry, the next event would probably be similar to that of summer 2014, less than 2 million m³.



Map: Norge digitalt



Rembesdalskåka photographed from helicopter on 14th October 2003. Photo: Hallgeir Elvehøy, NVE



Lower Demmevatn on 3rd September 2013 and immediately after a jøkulhlaup on 26th August 2014. Photos: Miriam Jackson, NVE and Vidar Riber, Statkraft.

Events:

1736 – 1938 – Jøkulhlaups from Demmevatn; recorded events as follows:

1736 – Earliest observation of flood.

1813 – Flood damage.

1842 – Flood damage.

17/09/1861 – Jøkulhlaup. Two bridges destroyed.

08/1893 – Jøkulhlaup. A basin of 35 million m³ drained in 24 hours, giving a mean discharge was about 400 m³/s (Liestøl, 1956). The water level of Demmevatn before the flood was about 1310 m a.s.l. (Rosendahl, 1938), which is approximately the same altitude as Demmevasshytta.

17/08/1897 – Jøkulhlaup. Water level in Demmevatn rose above the height of the glacier surface. Water drained over the glacier surface and melted down into the ice and made a crevasse to the bottom of the glacier. The crevasse reached the bottom of the glacier on 12th September, after 26 days, and Demmevatn was empty. This was probably the normal way of emptying before 1893 (Liestøl, 1956). Simadalen flooded. Draining of 35 mill m³ water in 26 days means that the mean discharge was about 15 m³/s plus normal drainage to Demmevatn (4 m³/s).

10/08/1937 – Jøkulhlaup. 11.5 million m³ drained in 3.5 hours, hence a mean water discharge of 900 m³/s (Liestøl, 1956). The drainage tunnel in the bottom of Demmevatn had a diameter of 5 m. Flood. The time at which the flood started is not well constrained. 165 000 NOK worth of damage.

23/08/1938 – Jøkulhlaup. This flood started before the new drainage tunnel was finished. The water level was observed at different times and compared with the height of the tunnel from 1899. 06:00 - 0 m (1286), 06:30 - 5 m (1281), 09:30 - 25m (1261), 13:20 - empty (1207). The drainage took place through a tunnel at the bottom of Demmevatn. The channel was closed by ice pressure and was totally blocked by 28th October with the result that Simadalen flooded. At 6 a.m. observations from the exit of the new tunnel showed there was no water in the old tunnel. Since the water discharge into Demmevatn was about 4 m³/s, (measured in 1897, Liestøl 1956), the discharge out of the lake, under the glacier, must have been more than this. This means that the jøkulhlaup could have started long before the first observations were made.

06/08/1998 – Mountaineering accident. Man (22), participant in a glacier course, tripped in crampons, slipped on ice and fell about 10 m into a crevasse. Broken bones in hand and thumb, black eye. Rescued by instructors and a medical doctor that also participated in the course. Glacier conditions probably misjudged and little experience (Norges Klatreforbund).

30/06/2000 – Mountaineering accident. During practice of rescue techniques, ice from the top of crevasse fell down into the crevasse and hit someone there (woman, 28). One injured; muscle and damaged ankle. (Norges Klatreforbund).

13/08/2000 – Mountaineering accident. Female (40 – part of glacier course), probably with little experience in walking in rough terrain, fell one metre into a crevasse, from overhanging snow to a snow-filled crevasse. She had an unlucky landing, which resulted in several broken bones. Rescued by instructors and transported to hospital by helicopter (Norges Klatreforbund).

04/08/2003 – Mountaineering accident. One person fell into a crevasse while traversing. Fell 1.5 m, ended up hanging in rope. Pain in chest, head and leg, possible broken rib (Norges Klatreforbund).

03/09/2005 – Mountaineering accident.

25/08/2014 – Jøkulhlaup. Lake level 1238 masl. People staying at the nearby DNT cabin, Demmevasshytta, heard a rumbling sound on the evening of 25th August. The next day they saw that the glacier-dammed lake, lower Demmevatn, had drained. Subsequent calculations by Statkraft showed that the inflow to Rembesdalsvatnet, part of their hydropower reservoir system, increased by about 2 million m³ in only three hours.

Monitoring: Mass balance measurements: Norwegian Polar Institute 1963–1984, NVE from 1985.

Front position measurements NVE/Statkraft in 1918-41, 1968-83 and from 1995.

Detailed map surveys in 1961 and 2010. Meteorological observations.

Future risks: The most recent jøkulhlaup occurred in August 2014, 76 years after the previous event. This followed extensive thinning of the lowermost part of the glacier over the preceding years and shows that after a long period of stability due to construction of drainage tunnels, Demmevatn should again be considered a potential risk.

Demmevasshytta at Remesdalsskåka is a popular place for glacier courses, so mountaineering accidents will occasionally happen.

References: Elvehøy, H., R.V.Engeset, L.M. Andreassen, J. Kohler, Y. Gjessing and H. Björnsson. 2002. Assessment of possible jøkulhlaups from Lake Demmevatn in Norway. In *The Extremes of the Extremes: Extraordinary Floods*. Wallingford, Oxon, International Association of Hydrological Sciences, pp. 31–36. (IAHS Publication 271).

Elvehøy, H., J. Kohler, R.V. Engeset and L.M. Andreassen. 1997. Jøkulhlaup fra Demmevatn. *NVE-Rapport* nr 17, 1997, 36 p.

Liestøl, O. 1956. Glacier Dammed Lakes in Norway. *Norsk geografisk tidsskrift* nr. 3-4. Bind XV, 1955-1956, h. 3-4.

Norges Klatreforbund.

Rosendahl, H. 1938. Rembesdalskåki og Demmevatn på Hardangerjøkulen. *Naturen* 1938.

NVE glacier database, Norge digitalt.

Rundvassbreen / Blåmannsisen (N)

Location: Fauske, Nordland.

Latitude: 67.29° N, Longitude: 16.04° E

WGI-ID: N4A000DI021

NVE-Atlas-ID: 941

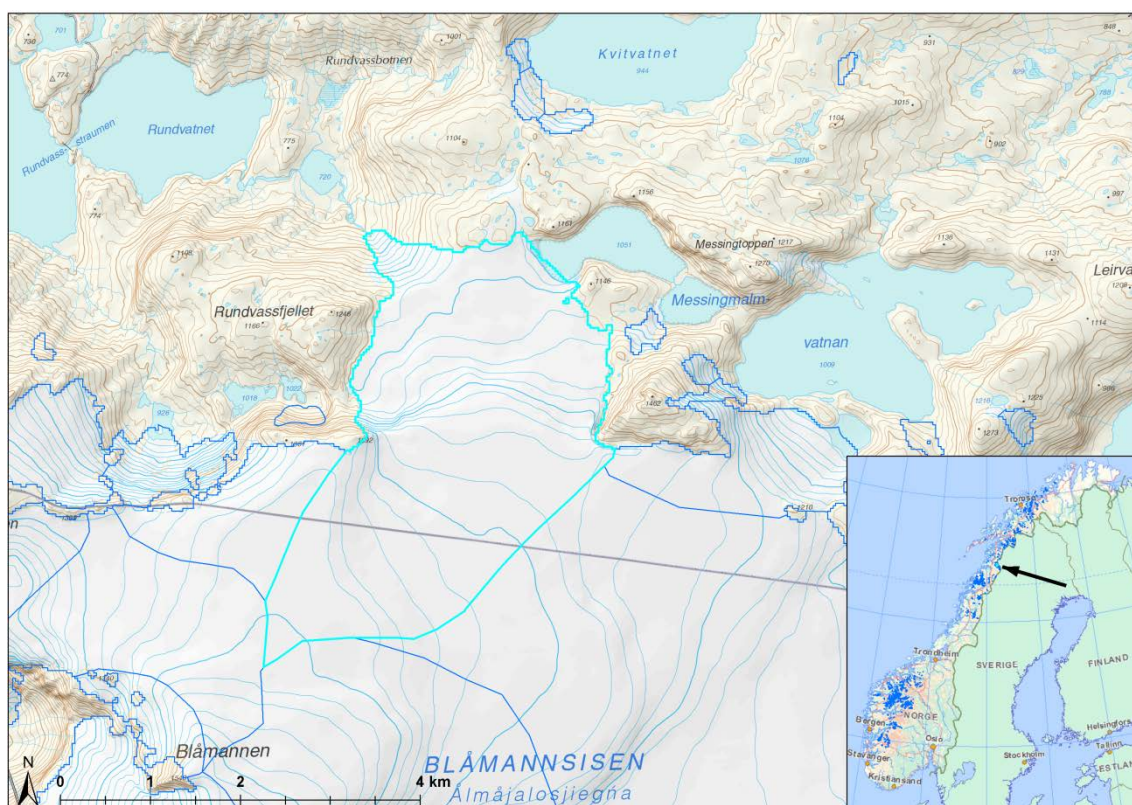
Dimensions: Area: 11.12 km², length: 6.3 km

Altitudinal range: 838 – 1419 m a.s.l.

Glacier type: Outlet glacier

Event type: Jøkulhlaup

Description: Northern outlet from Blåmannsisen ice cap. It is situated between Rundvassfjellet mountain summit to the west and Messingtoppen mountain to the east. Rundvassbreen drains to the hydropower reservoir, Sisovatnet, through Rundvatnet lake. On its eastern side, the glacier dams Messingmalmvatnet lake system, with Øvre Messingmalmvatnet lake immediately adjacent to the glacier.



Map: Norge digitalt

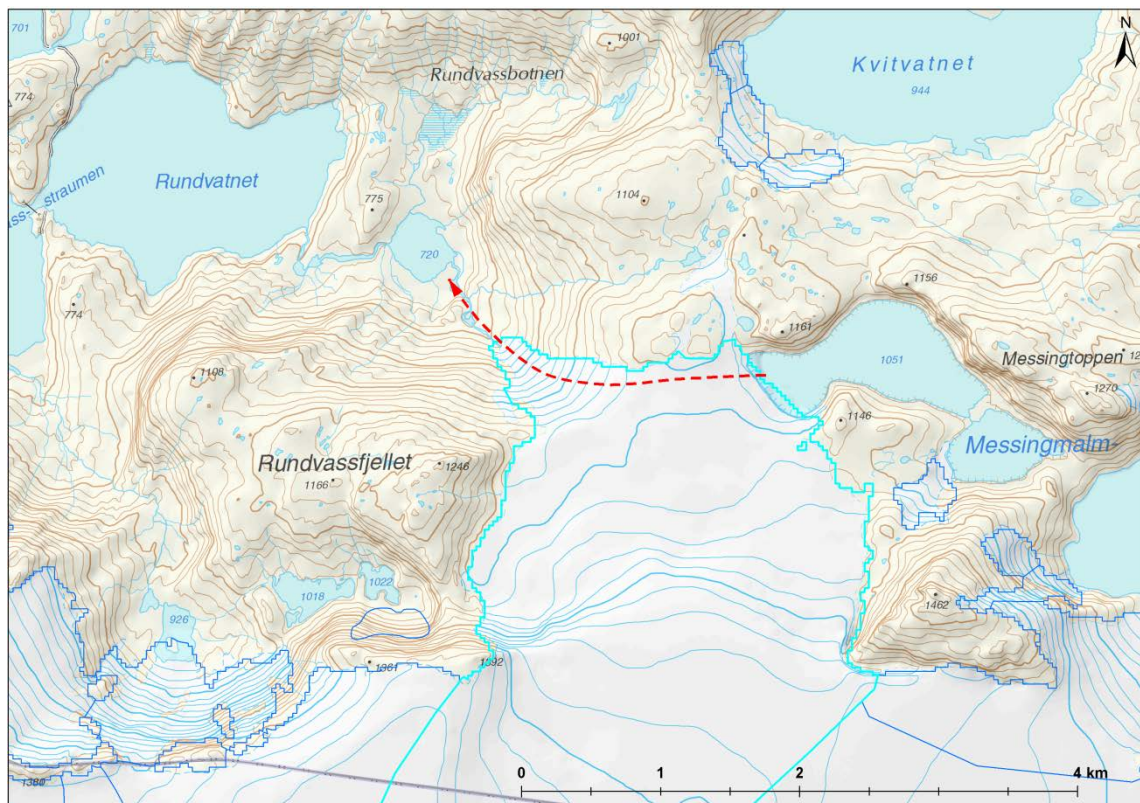


Messingmalmvatnet glacier-dammed lake and Rundvassbreen photographed from helicopter in 2002. The drained lake and glacier front is visible on the photo. Photo: Hans Martin Hjemås

Events:

05/09/2001 – Jøkulhlaup. Subglacial drainage of a glacier-dammed lake – upper Messingmalmvatn (called Vatn 1051). This is the first recorded jøkulhlaup from the lake, and is probably a direct result of climate change that has made the glacier thinner so that it no longer efficiently dams the lake. The event lasted 35 hours with an estimated peak discharge of $800-900 \text{ m}^3 \text{ s}^{-1}$. The drained lake was almost completely emptied when its water level dropped about 50 m, causing water level in the hydropower reservoir, Sisovatnet, to increase by about 2.5 m. The drainage added an expected 40 mill m^3 of water to the Siso hydropower plant reservoir (Engeset, 2001).

See also section 4.2 (p.182) for more information.



Map: Norge digitalt

29/08/2005 – Jøkulhlaup. 35 mill m³ water drained in 36 hours. This volume can produce 50 million kWh of electricity. The water level in the Sisovatn hydropower reservoir increased 2.5 m. The maximum discharge was estimated at about 840 cubic metres per second at 2 am on Tuesday 30th August. The jøkulhlaup caused no damage and was anticipated (Engeset et al., 2005).

29/08/2007 – Jøkulhlaup, 20 mill m³ (Kjøllmoen et al., 2010).

06/09/2009 – Jøkulhlaup, 20 mill m³ (Kjøllmoen et al., 2010).

08-17/09/2010 – Jøkulhlaup from Øvre Messingmalmvatnet drained under Rundvassbreen (Kjøllmoen et al., 2011).

22/09/2011 – Jøkulhlaup from Øvre Messingmalmvatnet. The volume of water was approximately 12 mill m³ (Kjøllmoen et al., 2012a).

11/08/2014 – Jøkulhlaup from Øvre Messingmalmvatnet. The volume of water was approximately 35 mill m³ making this the biggest event since 2005.

Monitoring: An extensive measurement campaign was initiated after the initial jøkulhlaup in 2001. The goal of this research was to try to predict the next jøkulhlaup. A series of instruments were deployed to monitor the next event. Geophones placed in the glacier ice and in bedrock recorded ice quakes two days before the start of the 2005-jøkulhlaup. Radar measurements of glacier thickness.

Mass balance measurements in 2002-04 and from 2011, front position measurements from 2011. Detailed map surveys in 1961, 1998 and 2011.

Future risks: Jøkulhlaups will probably continue to occur when the water level in the lake is high enough.

References: Engeset, R.V., 2001. Climate change results in jøkulhlaup at Blåmannsisen. *NVE Monthly Hydrology Report* (in Norwegian), September 2001.

Engeset, R.V., T.V. Schuler and M. Jackson. 2005. Analysis of the first jøkulhlaup at Blåmannsisen, northern Norway, and implications for future events. *Ann. Glaciol.*, 42, pp. 35–41.

Kjøllmoen, B., 2012a. Breundersøkelser på Blåmannsisen. Årsrapport 2011. Oppdragsrapport B 7. 2012.

Kjøllmoen, B., L.M. Andreassen, H. Elvehøy, M. Jackson and R.H. Giesen. 2011. Glaciological investigations in Norway in 2010. NVE Report 3, 89p.

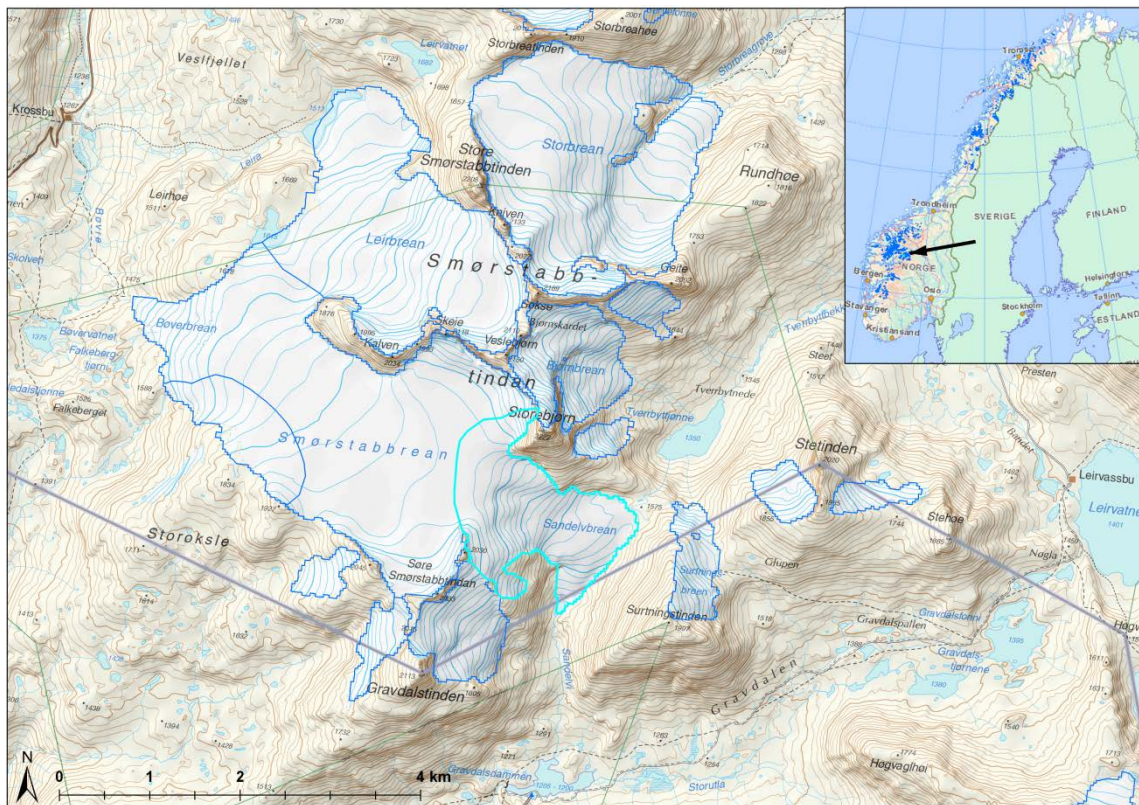
Kjøllmoen, B., L.M. Andreassen, H. Elvehøy, M. Jackson and R.H. Giesen. 2010. Glaciological investigations in Norway in 2009. NVE Report 2, 85p.

NVE glacier database, Norge digitalt.

Sandelvbrean

Location:	Lom, Oppland. Latitude: 61.54° N, Longitude: 8.15° E
WGI-ID:	N4A000A1018
NVE-Atlas-ID:	2652
Dimensions:	Area: 2.36 km ² , length: 2.4 km
Altitudinal range:	1393 – 2141 m a.s.l.
Glacier type:	Outlet glacier
Event type:	Mountaineering accident

Description: A south-east outlet from Smørstabbrean ice cap in central Jotunheimen. Sandelvbrean is situated between the mountain summits Storebjørn (2222 m a.s.l.) and Surtningstinden (1997). The glacier shares its western boundary with Bøverbreen glacier and drains to Sandelvi river then to Gravdalsdammen.



Map: Norge digitalt



www.norgebilder.no (28.09.2010)

Events:

August 1945 – Mountaineering accident. A man (Erling Jahr, a geologist from Oslo) and a woman fell into a crevasse and died. The bodies were found in 1978, more than 30 years later (Dagbladet 19/08/1978).

21-22/03/1967 – Mountaineering accident. Four skiers died on the glacier. There is a memorial plaque for them in the upper part of the glacier.

During bad weather one experienced mountaineer started a trip from Krossbu to Leirvassbu across Bøverbreen and Sandelvbreen glaciers, with seven other people. After they crossed Bøverbreen and were going to continue over Sandelvbreen between Storebjørn and Surtningstinden, they encountered difficulties and decided to dig a shelter in the snow. However, they did not have a shovel and several of them were physically and mentally exhausted by then. The experienced person decided to go Leirvassbu to call for help. It was not possible to start a rescue operation until the next day (Nordli, 2000).

In the morning one person started walking towards Leirvassbu after she and her friend managed to stay awake through the night. She was the only one of the seven who did not have physical injuries. On the way she met the rescue team and helped them finding the others. Her friend was found alive leaning on ski poles with foot injuries, but the other four were dead. The third man had serious injuries (Nordli, 2000).

Monitoring: –

Future risks: The usual risks apply for glacier walking and ice climbing.

References: Dagbladet 19/08/1978.

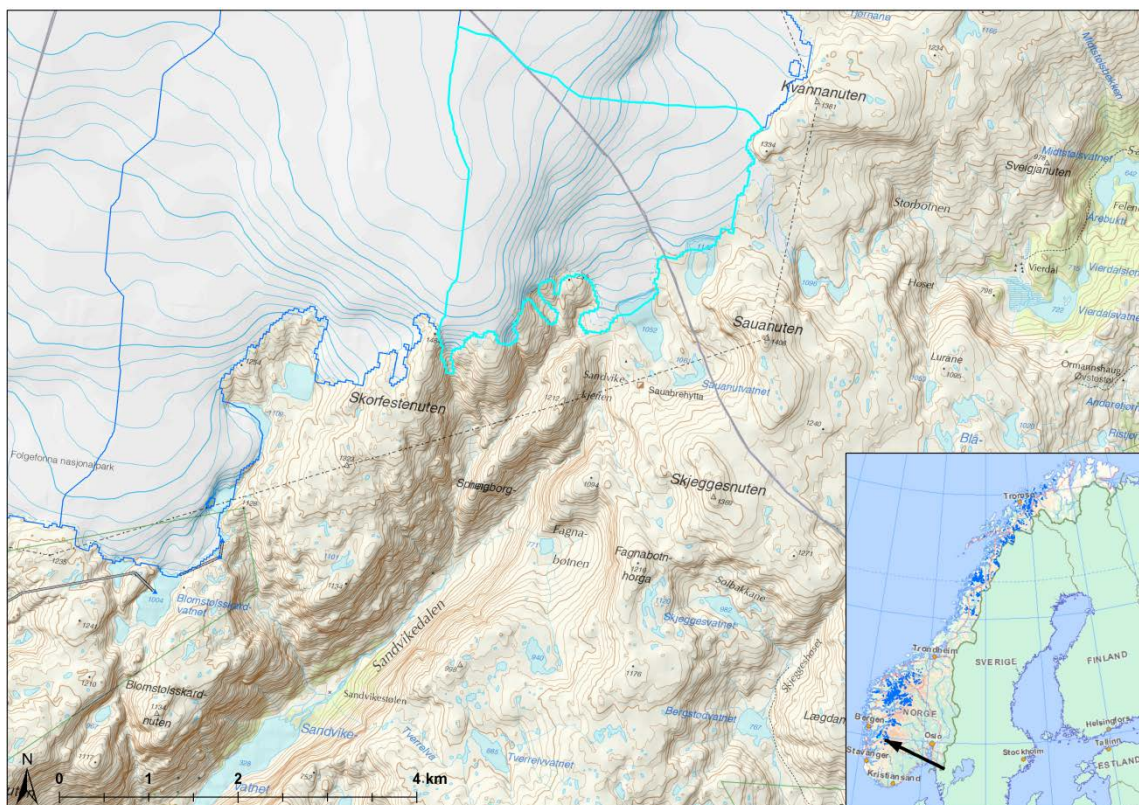
Nordli, Ø. 2000. Fjellet i snø, vind, sol og tåke: handbok for fjellturen. *Samlaget, Oslo*, 2000. pp. 66-69.

NVE glacier database, Norge digitalt, www.norgebilder.no.

Sauanutbreen

Location:	Etna and Odda, Hordaland. Latitude: 59.98° N, Longitude: 6.41° E
WGI-ID:	N4A000AK008
NVE-Atlas-ID:	3142
Dimensions:	Area: 7.65 km ² , length: 4 km
Altitudinal range:	1056 – 1585 m a.s.l.
Glacier type:	Outlet glacier
Event type:	Jøkulhlaup

Description: Sauanutbreen is the easternmost outlet glacier from the southern part of Søndre Folgefonna ice cap where three major glacier tongues emerge, and is also the smallest. It drains into the river Londalselv. In 1959 Sauanutbreen reached down to 950 m a.s.l. A river from the glacier flows in rapids along the narrow Sandvikdalen gorge, through the 2.5 km long lake of Sandvikvatn then to the valley Londalen until it empties into Åkrafjorden at Mosnes, a delta flat formed by Londalselva. The total distance is about 15 km.



Map: Norge digitalt

In the 1930s when Sauanutbreen started retreating, between four and six farms had their buildings and most of their cultivated land on the delta flat and on the terraces along the river. There were no roads connecting Mosnes to other settlements, and therefore the fjord provided the

main transport route. In many ways Mosnes was typical of the settlements in the fjord districts of western Norway at that time.



Sauanutbreen photographed on 1st September 1994. Photo: Arve Tvede

Events:

1938-1962 – Jøkulhlaups from lake Sauanutvatnet.

30/07/1938 – Jøkulhlaup. Considerable flood damage in the village of Mosnes, at Åkerfjorden, both to buildings and to cultivated land. The school building was destroyed and three bridges were washed away. 8000 m² of cultivated land were damaged.

19/08/1944, 27/09/1948 – Jøkulhlaup. Large floods following several days of heavy rain and jøkulhlaups from lake Sauanutvatnet. The flood protection structures at Mosnes were damaged and had to be repaired.

18/10/1962 – Jøkulhlaup. The fourth catastrophic flood occurred, causing more damage at Mosnes than previous floods. Much of the cultivated land was destroyed, and it was considered too expensive to repair the flood protection structures again. The farmers at Mosnes were thus offered support from the State to enable them to leave Mosnes and settle elsewhere.

Monitoring: After the first jøkulhlaup in 1938 that was partly due to heavy rainfall, the State River Maintenance Department built flood-protection structures along the banks of the river Londalselv. However, these structures were substantially damaged in the floods in 1944, 1948 and 1962.

Ice thicknesses on parts of Sauabreen were measured by NVE using radar in 1987 (Kennett and Sætrang, 1987).

Future risks: No floods that have caused damage have been reported since 1962. A field visit in July 1988 showed that Sauavatn can no longer be considered to be a true glacier-dammed lake (Tvede, 1989).

Taking into consideration the fact that since 1966 there has been no permanent settlement on the site in Mosnes, even though the existing houses are still used in summer for recreational purposes, and due to glacier retreat, there is no present risk of damage from a jøkulhlaup.

References: Kennett, M. and A. C. Sætrang. 1987. Istykkelsesmålinger på Folgefonna. *NVE-Oppdragsrapport 18-87*.

Tvede, A. M. 1989. Floods caused by a glacier-dammed lake at the Folgefonni ice cap, Norway. *Annals of glaciology* 13 (1989), pp. 262–264.

NVE glacier database, Norge digitalt.

Sikilbreen

Location: Luster, Sogn & Fjordane.
Latitude: 61.87° N, Longitude: 7.4° E

WGI-ID: N4A000AE032

NVE-Atlas-ID: 2457

Dimensions: Area: 8.56 km², length: 4.1 km

Altitudinal range: 1205 – 1739 m

Glacier type: Outlet glacier

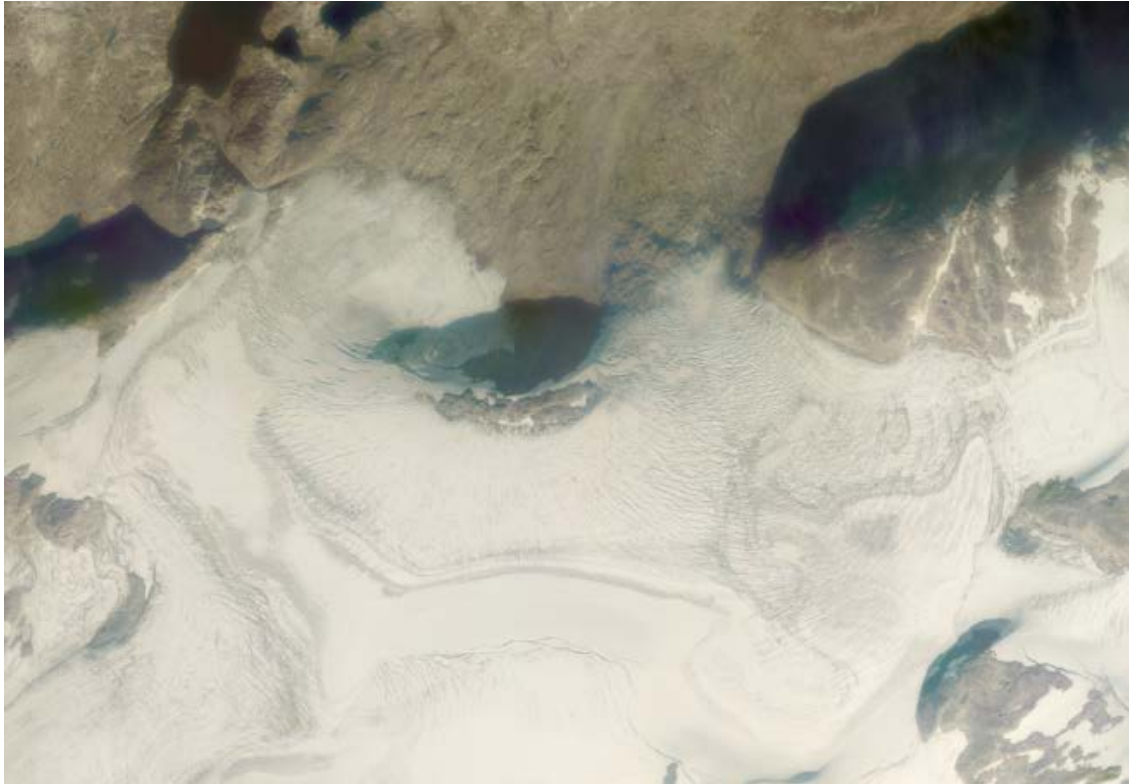
Event type: Mountaineering accident

Description: A northern outlet from Jostedalsbreen ice cap, situated between Sygneskarsbreen glacier to the south-west and Tverrbytnbreen glacier to the south-east. Sikilbreen drains to Ytste Leirvatnet lake.

As late as the 1860s to 1870s the glacier occupied the valley between Merradalsbotn glacial cirque and Nedre Leirvatnet lake on the old road between Sunndalen valley in Oppstryn municipality and Rauddalen valley in the municipality of Skjåk. There was an old road between Norfjord and Gudbrandsdalen, used by horses and cattle as well as travellers, such as people from Nordfjord who worked in the copper mills in Røros in the 18th century (Eide, 1955).



Map: Norge digitalt



www.norgebilder.no (05.09.2010)

Events:

1838 – Mountaineering accident. A farmer from Oppstryn was in the town of Lom selling apples. On the way back over the glacier he fell into a crevasse and died. His horse returned home and the body of the farmer was found the following year (Eide, 1955).

Monitoring: –

Future risks: Usual risks associated with glacier walking and climbing.

References: Eide, T.O., 1955. Breden og bygda. *Noreg Tidsskrift for folkelivsgransking*, Vol. 5, pp. 1-40.

NVE glacier database, Norge digitalt, www.norgebilder.no.

Slingsbybreen

Location: Årdal and Luster, Sogn & Fjordane.
Latitude: 61.46° N, Longitude: 7.88° E

WGI-ID: N4A000A1009

NVE-Atlas-ID: 2694

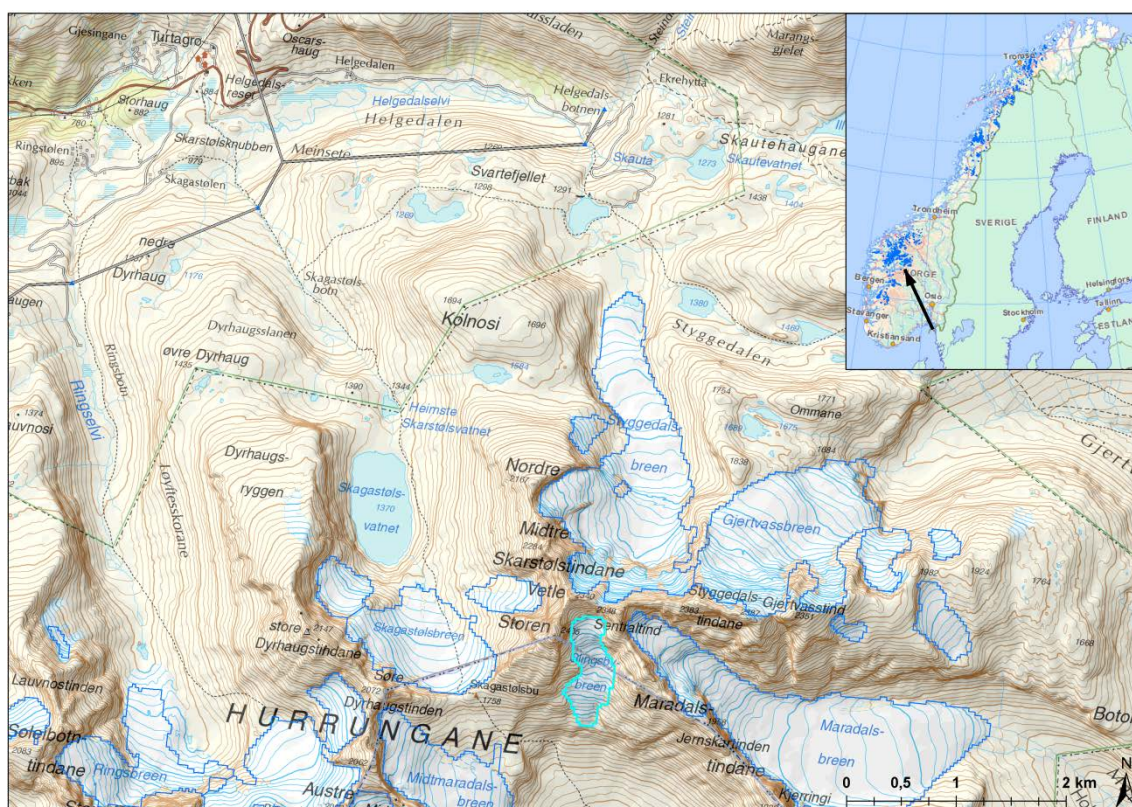
Dimensions: Area: 0.29 km², length: 1.1 km

Altitudinal range: 1550 – 2138 m

Glacier type: Mountain glacier

Event type: Mountaineering accident

Description: A small mountain glacier situated in Hurrungane mountains in Western Jotunheimen between Skagastølsbreen glacier to the west, Maradalsbreen glacier to the east and Styggedalsbreen to the north. Slingsbybreen drains to Midtmaradøla river in Midtmaradalen valley.



Map: Norge digitalt



www.norgebilder.no
(28.09.2010)

Events:

04/10/1986 – Mountaineering accident. A 30 year old Swedish man died and two other trip participants were injured in an accident by the mountain summit of Store Skagastølstind in Western Jotunheimen. The accident happened on the eastern side of the mountain, when the three were on the way down from Slingsbybreen glacier. They slid 400-500 m down after one of them lost their footing and dragged along the others in the rope team. One of them, who had significant leg injuries, managed to get to Turtagrø during the night (about 7.4 km north-west from the glacier along a path) to call for help (Aftenposten 06/10/1986).

Monitoring: –

Future risks: Usual risks associated with glacier walking and climbing.

References: Aftenposten 06/10/1986.

NVE glacier database, Norge digitalt, www.norgebilder.no.

Snøggeken (Falkbreen)

Location: Årdal, Sogn & Fjordane.
Latitude: 61.39° N, Longitude: 8.11° E

WGI-ID: N4A000A1036

NVE-Atlas-ID: 2729

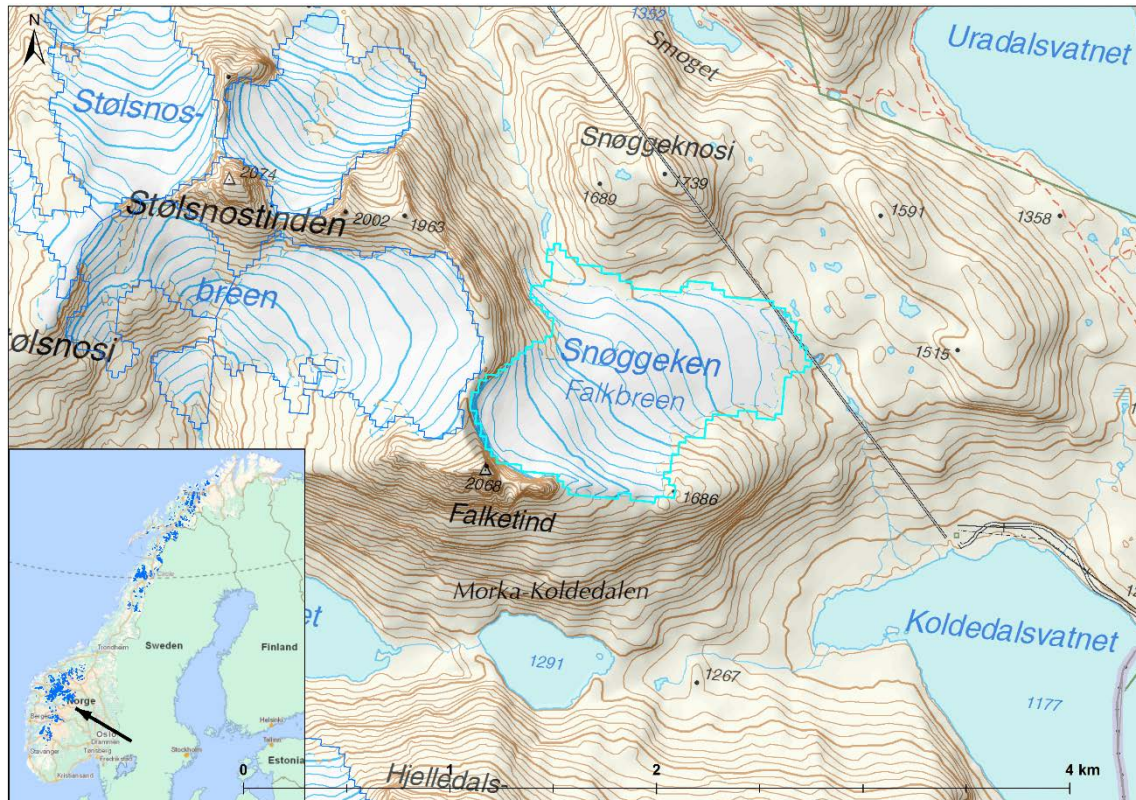
Dimensions: Area: 1.18 km², length: 1.7 km

Altitudinal range: 1409 – 1850 m

Glacier type: Mountain glacier

Event type: Mountaineering accident

Description: A small mountain glacier situated east of Stølsnosbreen glacier. These two glaciers are divided by a sharp mountain ridge between Stølsnostinden and Falketind peaks. Snøggeken glacier drains to both Koldedalsvatnet lake from its main tongue and to Fleskedøla river from its smaller northern tongue. Snøggeken has an alternative name, Falkbreen, which is widely used locally.



Map: Norge digitalt



www.norgebilder.no (28.09.2010)

Events:

08/10/2005 – Mountaineering accident. A female member of a group fell about 100 m from a steep slope of Snøggeken glacier between Falketind and Stølsnostinden mountain peaks and disappeared. Her group members did not manage to find her after climbing down where she fell. She was found dead next day by a local rescue team (VG.no 08.10.2005, 09.10.2005)

Monitoring: –

Future risks: Usual risks associated with glacier walking and climbing.

References: <http://www.vg.no/nyheter/innenriks/klatregruppe-skal-hente-kvinne-i-breskraaning/a/292686/>
<http://www.vg.no/nyheter/innenriks/savnet-kvinne-funnet-dod-ved-isbre/a/108200/>

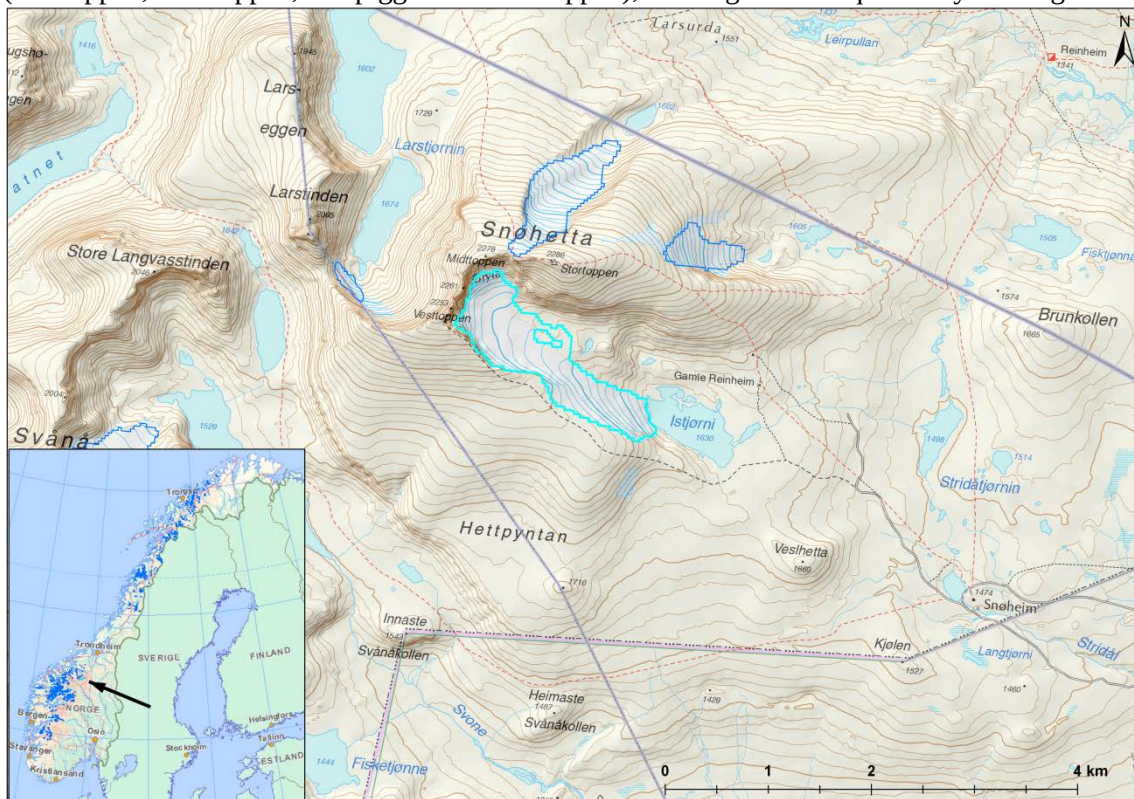
NVE glacier database, Norge digitalt, www.norgebilder.no

Snøhetta (S)

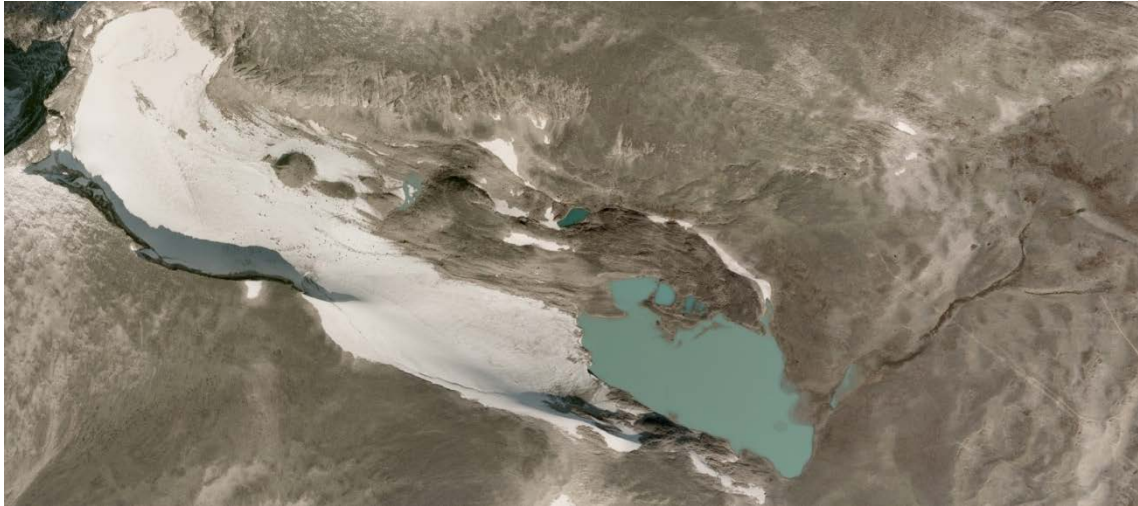
(This name is unofficial and refers to the location of the glacier in the area called Snøhetta)

Location:	Dovre, Oppland. Latitude: 62.31° N, Longitude: 9.26° E
WGI-ID:	N4A000CJ020
NVE-Atlas-ID:	1738
Dimensions:	Area: 1.03 km ² , length: 2.3 km
Altitudinal range:	1638 – 2083 m
Glacier type:	Mountain glacier
Event type:	Mountaineering accident

Description: A small unnamed mountain glacier situated on Snøhetta mountain in the center of the Dovre and Sunndalsfjella national park. The glacier breaks out into Istjønnei Lake. This is actually the eastern-most glacier in the southern part of Norway (<http://naturperler.com/default.asp?pageid=5600>). Snøhetta is the highest mountain in the Dovrefjell range, and the highest mountain in Norway outside of the Jotunheimen range, making it the 24th highest peak in Norway. Snøhetta is a large curved alpine ridge with four summits (Stortoppen, Midttoppen, Hettpiggen and Vesttoppen), forming a vast cirque valley with a glacier.



Map: Norge digitalt



www.norgebilder.no (15.09.2009)

Events:

18-22/10/2013 – Mountaineering accident. The exact date is unknown. A 53 year old Polish man, Leszbek Piotr Zochowski, drowned in a 3-4 metre deep crevasse underneath Snøhetta glacier at Dovrefjell. A leisure diver, he dived in ponds and grottos in Istjørni lake east of Snøhetta. His dead body was found in the crevasse a day after he was reported missing from “Snøheim” tourist cabin where he left his bicycle (Sletmoen, A. S. & Holø, R. M. (www.nrk.no), 23.10.2013; Rikoll, M. & Rostad, K. (www.nrk.no), 23.10.2013).

Monitoring: –

Future risks: Usual risks associated with glacier walking and climbing.

References: Rikoll, M. & Rostad, K. (www.nrk.no), 23.10.2013: <http://www.nrk.no/ho/soker-fortsatt-etter-savnet-mann-1.11313628>

Sletmoen, A. S. & Holø, R. M. (www.nrk.no), 23.10.2013: <http://www.nrk.no/ho/dod-person-hentet-ut-fra-bresprekk-1.11315469>

Norske Naturperler (<http://naturperler.com/default.asp?pageid=5600>)

NVE glacier database, Norge digitalt, www.norgebilder.no

Steindalsbreen

Location: Tromsø & Storfjord, Troms.
Latitude: 69.39° N, Longitude: 19.85° E

WGI-ID: N4A000EH053

NVE-Atlas-ID: 288

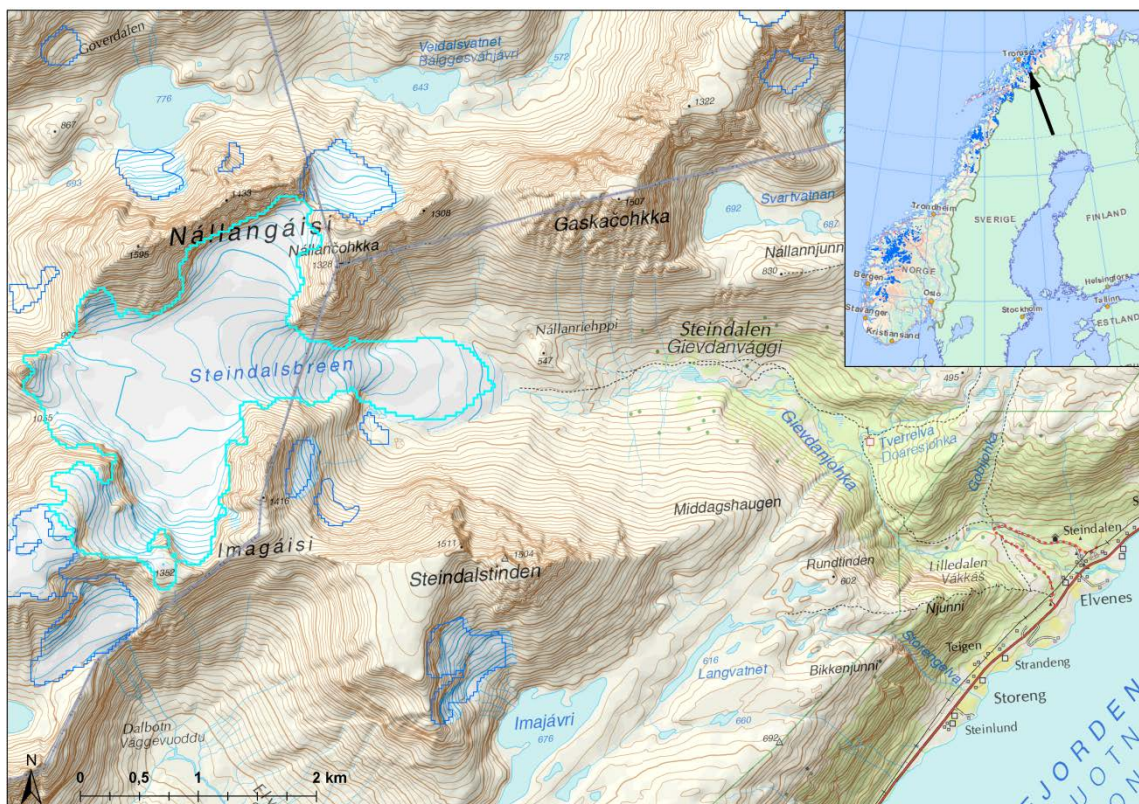
Dimensions: Area: 5.14 km², length: 5.3 km

Altitudinal range: 474 – 1504 m

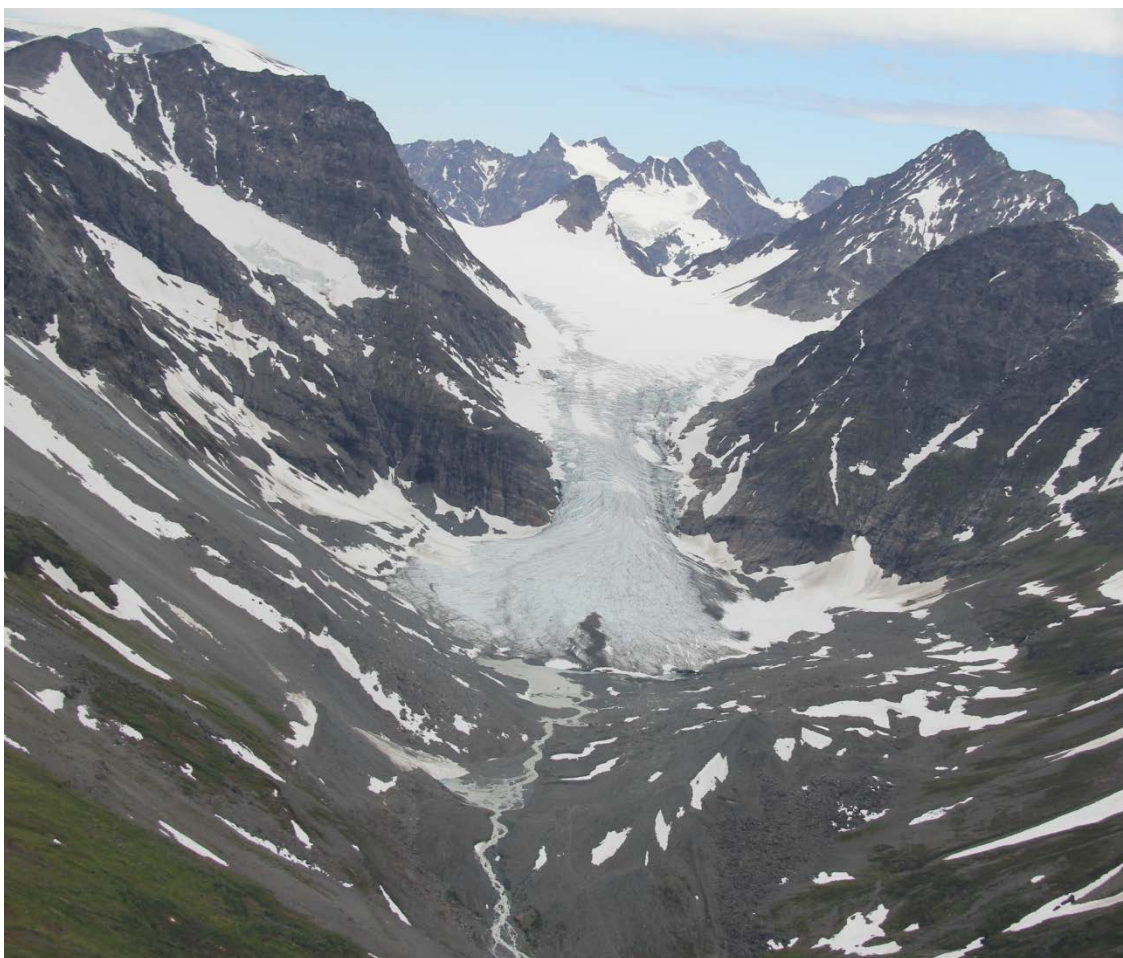
Glacier type: Valley glacier

Event type: Mountaineering accident

Description: Valley glacier situated in the southern part of Lyngen peninsula. The glacier drains to Storfjorden through Gievdanjohka (Steindalselva) river. Steindalsbreen is popular with visitors since it is easily accessible, with footpaths leading to the glacier tongue from the road.



Map: Norge digitalt



Steindalsbreen photographed from helicopter on 27th June 2013. Photo: Hallgeir Elvehøy, NVE

Events:

01/07/2010 – Mountaineering accident. First person in a rope team of three fell about 8 m into a crevasse through a snow bridge and became stuck. The team was unable to get him up again, and a rescue operation was triggered. No injuries (Norges Klatreforbund).

Monitoring: Front position measurements from 1998. Pictures taken in 1998, 2002, 2005-6, 2009-13.

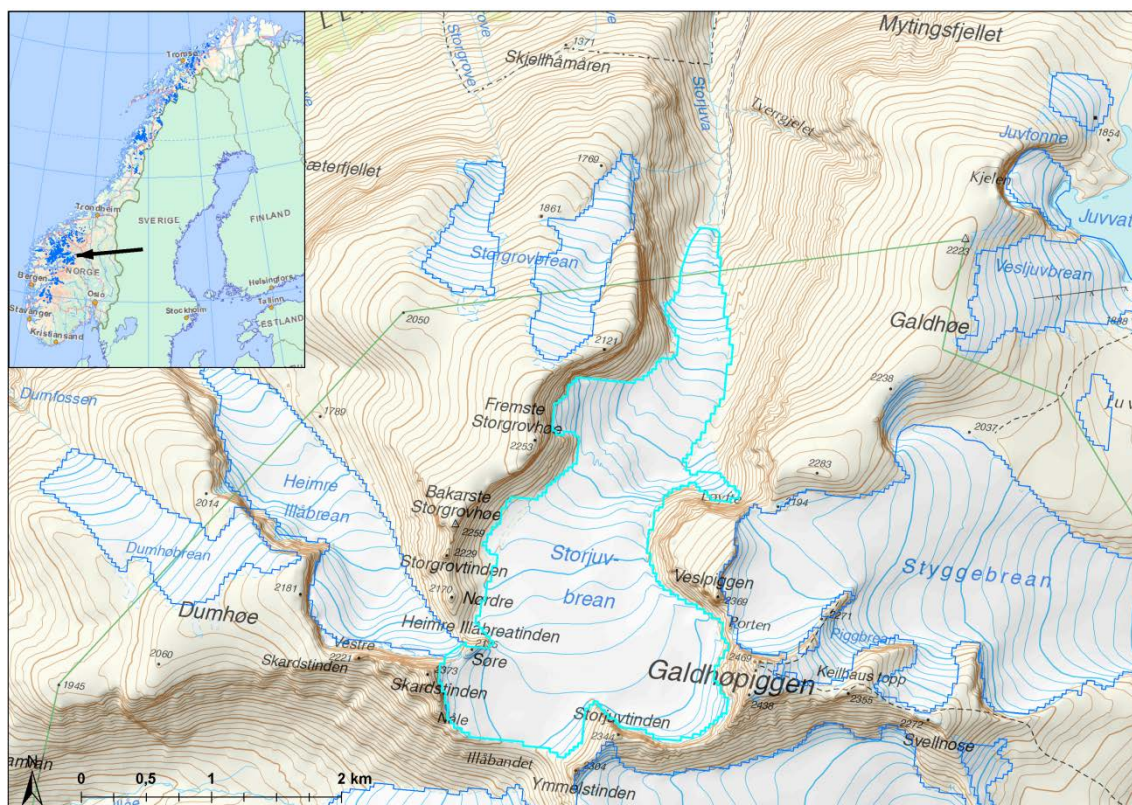
Future risks: Usual risks associated with glacier walking and climbing.

References: Norges Klatreforbund.
NVE glacier database, Norge digitalt.

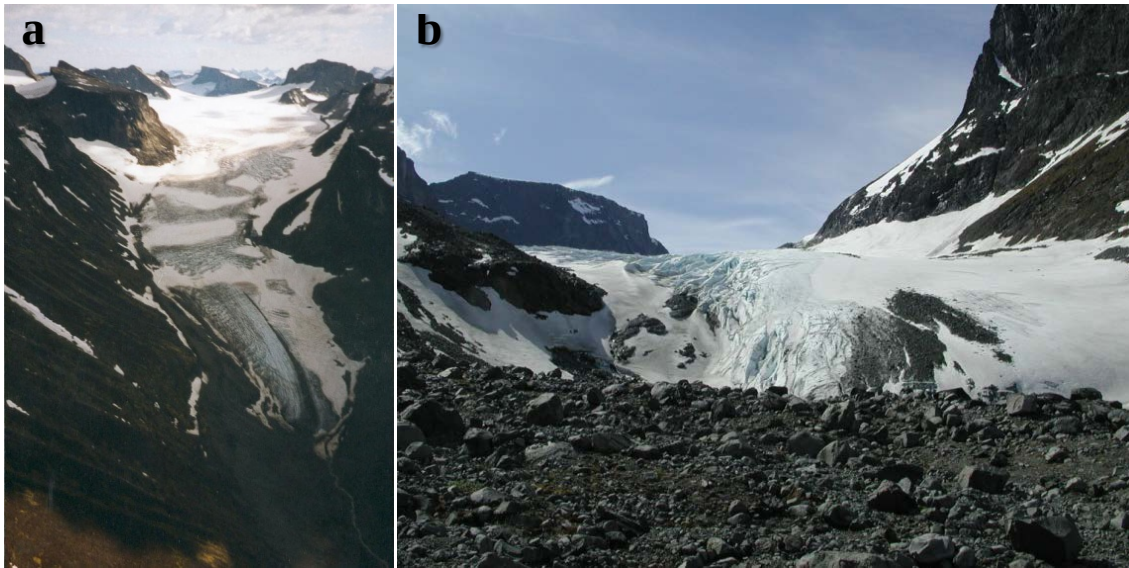
Storjuvbrean

Location:	Lom, Oppland. Latitude: 61.64° N, Longitude: 8.29° E
WGI-ID:	N4A000AD027
NVE-Atlas-ID:	2614
Dimensions:	Area: 4.49 km ² , length: 4.6 km
Altitudinal range:	1393 – 2223 m a.s.l.
Glacier type:	Valley glacier
Event type:	Mountaineering accident (rock avalanche)

Description: In Jotunheimen, north of Norway's highest mountain peak, Galdhøpiggen (2469 m a.s.l.), and between Heimre Illåbrean Styggebrean glaciers. Storjuvbrean drains to Storjuva river.



Map: Norge digitalt



a – Storjувbreen in 2002. Photo: NVE picture archive;

b – Storjувbreen glacier front photographed on 18th June 2003. Photo: Miriam Jackson, NVE.

Events:

July 2001 – Mountaineering accident. Sudden rock avalanche while two people were walking beneath the moraine ridge. Woman, 30, and man, 35, were participants in television program "71 grader nord". Woman rescued by helicopter and had head injuries. The man had minor hand injuries. Rock fall probably due to heavy rain (Norges Klatreforbund).

Monitoring: Front position measurements 1901-12, 1933-63, 1997- .
Detailed map survey in 2011.
Photos taken in 2002-03, 2005-06, 2010-11.

Future risks: Usual risks associated with glacier walking and climbing.

References: Norges Klatreforbund. NVE glacier database, Norge digitalt.

Strupbreen

Location: Lyngen, Troms.
Latitude: 69.71° N, Longitude: 20.13° E

WGI-ID: N4A000EH088

NVE-Atlas-ID: 200

Dimensions: Area: 9.51 km², length: 7.0 km

Altitudinal range: 481 – 1509 m a.s.l.

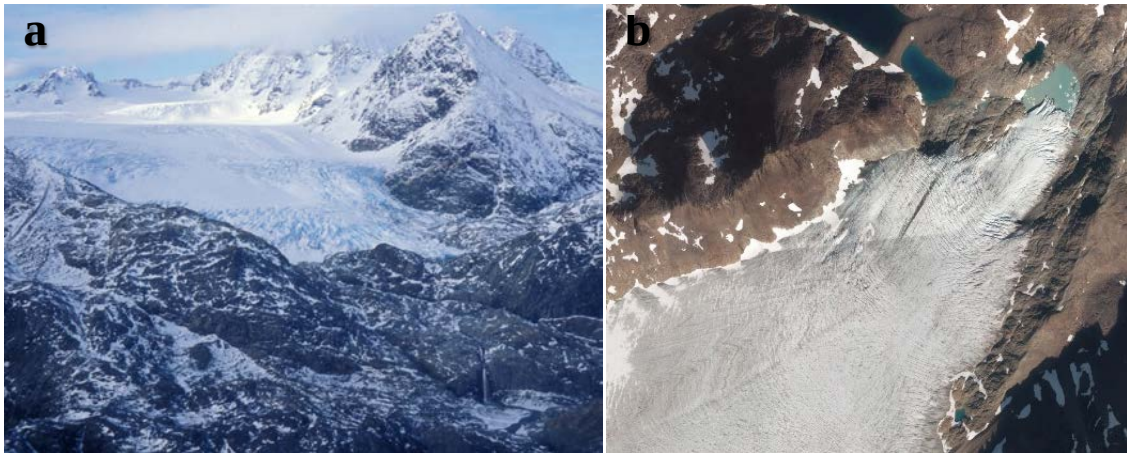
Glacier type: Valley glacier

Event type: Jøkulhlaup

Description: Strupbreen glacier is situated about 1-1.5 km south of Strupskardet – a valley crossing the northern part of the Lyngen peninsula. The glacier flows from southwest towards the eastern part of the couloir. During its maximum extent in the 18th century, Strupbreen probably extended almost to the sea. At present the glacier front is found about 1.5 km from the shore, on a steep slope about 500 m a.s.l. The glacier dams the lakes Strupvatnet situated in Strupskardet and a small nameless lake at the foot of Store Koppangstinden (1224 m a.s.l.) and Litle (1176 m a.s.l.).

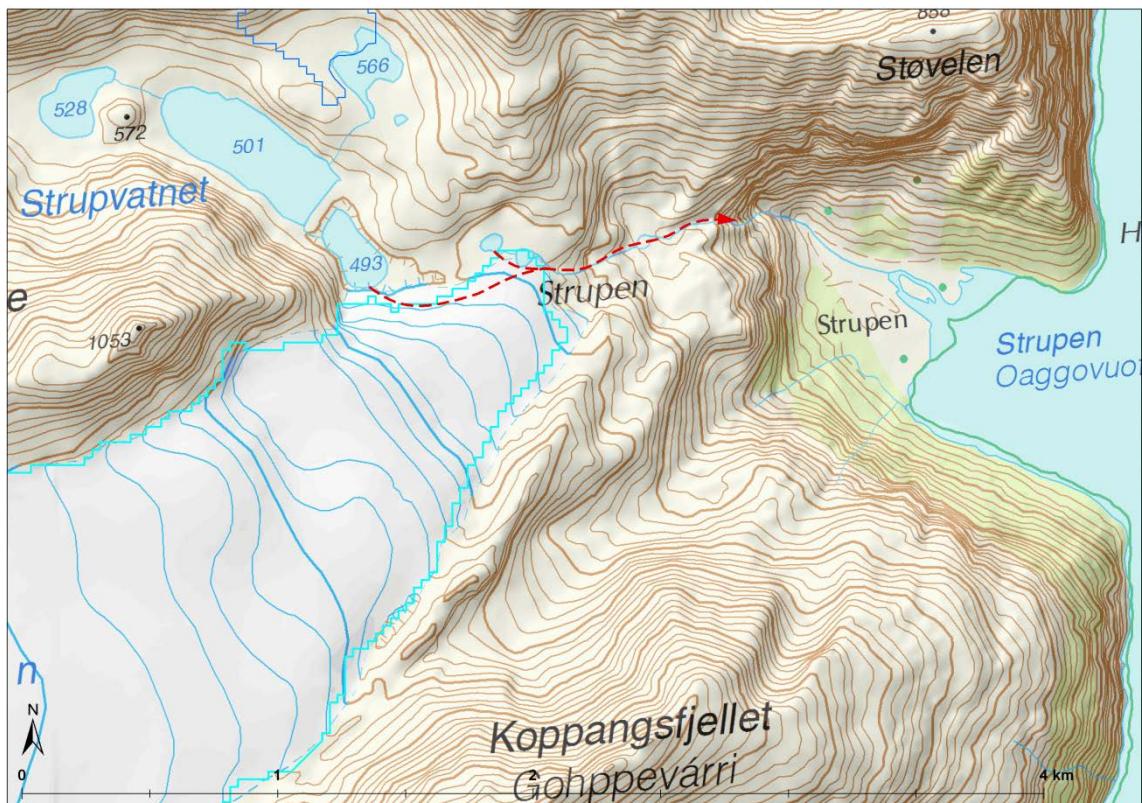


Map: Norge digitalt



a – The front of Strupbreen photographed on 12th January 2002. Photo: Bjarne Kjøllmoen, NVE;

b – Strupbreen by www.norgebilder.no (16.08.2011).



Map: Norge digitalt

Events:

1898 – Jøkulhlaup from lake Strupvatnet. No damage. It was reported by English climbers M. M. Hastings and C. Slingsby, who visited the district in 1898. They found a large lake filled with drifting ice blocks. However when they returned a few days later, the lake had drained, with only a little water left (Liestøl, 1956).

1969 – Jøkulhlaup from lake Strupvatnet. The volume of the lake was estimated as 4.6 mill. m³, while 2.6 mill. m³ were released during the outburst when the maximum discharge was 150 m³/s. No damage downstream was recorded (Whalley, 1971).

Monitoring: Monitored by NVE. Photos were taken in 1973, 1985, 1989, 1998, 2002.
Detailed map surveys in 1952, 1978, 1985, 1998 and 2010.

Future risks: Jøkulhlaup. Since Strupbreen glacier is located in an unpopulated area in northern Norway (Lyngen peninsula), there is no potential hazard to communities.

References: Liestøl, O. 1956. Glacier Dammed Lakes in Norway. *Norsk geografisk tidsskrift* nr. 3-4. Bind XV, 1955-1956, h. 3-4.

Vaksdal, M. and K. Melvold. Glacier Inventory in Norway. *Glaciorisk. EVG1 2000 00512*. Final report (2001-2003):

http://glaciorisk.grenoble.cemagref.fr/sec6_GLACIORISK_Other_Appendices.pdf

Whalley, W. B. 1971. Observations of the drainage of an ice-dammed lake – Strupevatnet, Troms, Norway. *Norsk Geografisk Tidsskrift*. Vol. 25, No. 3-4, pp. 165–174.

NVE glacier database, Norge digitalt, www.norgeibilder.no.

Styggebrean

Location:	Lom, Oppland. Latitude: 61.64° N, Longitude: 8.34° E
WGI-ID:	N4A000AD024
NVE-Atlas-ID:	2608
Dimensions:	Area: 4.92 km ² , length: 3.6 km
Altitudinal range:	1665 – 2415 m a.s.l.
Glacier type:	Valley glacier
Event type:	Mountaineering accident

Description: Styggebrean is in central Jotunheimen, east of Norway's highest mountain peak Galdhøpiggen, 2469 m a.s.l. It is probably the glacier in Norway that the most people have visited. Every day during summer hundreds of people cross the upper part with a guide to reach Galdhøpiggen. The glacier has several accumulation areas divided by mountain ridges. The glacier unit that comes all the way from the top of Galdhøpiggen, is sometimes referred to as Piggbrean glacier.



Map: Norge digitalt



www.norgebilder.no (29.09.2010)

Events:

20/07/1993 – Mountaineering accident. Man fell into a crevasse and died (Dagbladet 22/07/1993).

Summer 1995 – Mountaineering accident. One in a group of tourists crossing the glacier fell into a crevasse and hung there for 45 minutes before being pulled out (Aftenposten 01/07/1996).

13/09/2000 – Mountaineering accident. Woman (30) lost her balance on ice on her descent and tried to stop the fall with arms outstretched. Result: dislocated shoulder (Norges Klatreforbund).

7/08/2009 – Mountaineering accident. On the way down Galdhøppigen a member of an organised group, a woman in her 70s, stumbled and fell, then slid down Piggbrean. She died before she was able to be evacuated (Kippernes (VG), 07/08/2009).

27/07/2010 – Mountaineering accident. The third person (a 44 year old inexperienced climber) in a guided rope-team of ten fell into a crevasse through a snow-bridge while walking on the glacier and fell approximately 4 m. The people behind her were not able to pull her up. Another rope-team came to assist, and the woman was brought up after lying in the crevasse about 15-20 minutes. There was a stream of cold water in the crevasse, so she was hypothermic when she came up and had suffered injuries to her face, arms, hands and neck by the fall (Norges Klatreforbund).

Monitoring: Front position measurements from 2011.

Future risks: Crossing this glacier is the easiest way to reach the summit of Galdhøpiggen. A lot of inexperienced hikers try to cross the glacier without a guide, which may lead to accidents.

References: Aftenposten 01/07/1996, Dagbladet 22/07/1993.

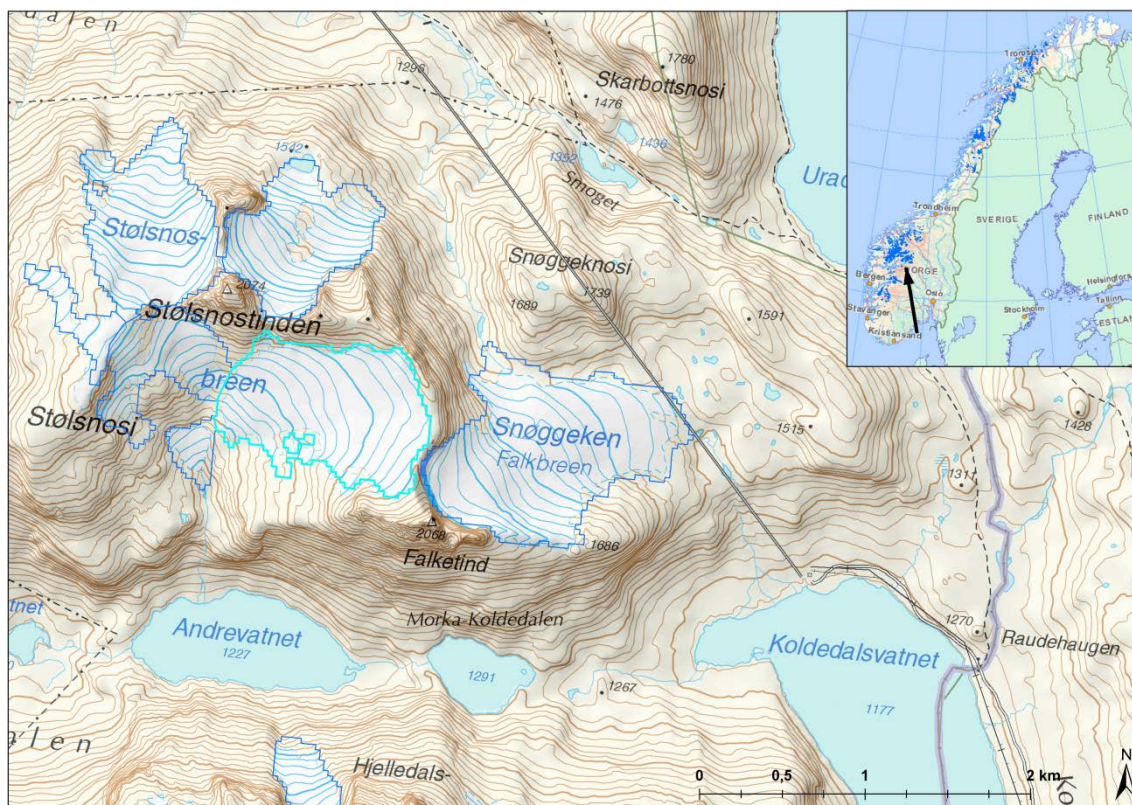
Kippernes, G.A. (VG) 07/08/2009
(<http://www.vg.no/nyheter/innenriks/doedsulykke-paa-galdhoepiggen/a/565989/>)

Norges Klatreforbund.

NVE glacier database, Norge digitalt, www.norgebilder.no.

Stølsnosbreen S

Location:	Årdal, Sogn & Fjordane. Latitude: 61.39° N, Longitude: 8.08° E
WGI-ID:	N4A000A1032
NVE-Atlas-ID:	2727
Dimensions:	Area: 0.87 km ² , length: 1.6 km
Altitudinal range:	1605 – 1919 m a.s.l.
Glacier type:	Cirque glacier
Event type:	Mountaineering accident
Description:	Cirque glacier surrounding Stølsnostind and Falketind in south western Jotunheimen, west of lake Bygdin and about 15 km southeast of Hurrungane. The peaks are very popular destinations, although physically demanding.



Map: Norge digitalt



www.norgebilder.no (22.08.2007)

Events:

24/08/2001 – Mountaineering accident. Two women (42 and 50), who were part of a guided trip, fell on steep ice. One of them lost her balance and slid, entangling the other woman in the fall. She slid 20-30 m on ice and then 15 m on rock. The first one had hand- and shoulder injuries, the second had serious facial and head injuries. They were unsecured walking across steep snow/ice passage on the way down. No experience with ice axe, difficult route, tired after a long day climbing/hiking and did not follow normal safety precautions. A helicopter aided rescue operations (Norges Klatreforbund).

Monitoring: –

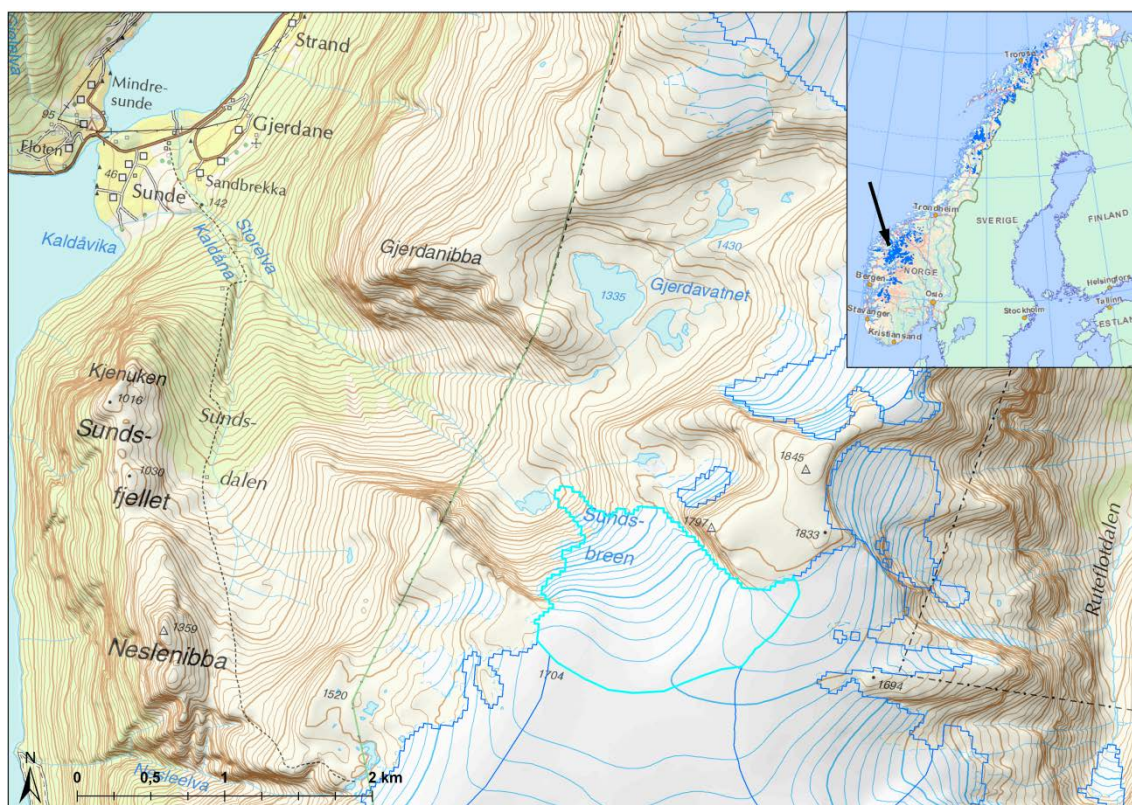
Future risks: The usual risks apply for glacier walking and ice climbing.

References: Norges Klatreforbund.

NVE glacier database, Norge digitalt, www.norgebilder.no.

Sundsreen

Location:	Stryn, Sogn & Fjordane. Latitude: 61.73° N, Longitude: 6.89° E
WGI-ID:	N4A000BS006
NVE-Atlas-ID:	2281
Dimensions:	Area: 1.47 km ² , length: 2.5 km
Altitudinal range:	1218 – 1786 m a.s.l.
Glacier type:	Outlet glacier
Event type:	Ice avalanche, Glacier length change
Description:	One of the western outlets from Jostedalsbreen ice cap. It is situated about 4 km south-east of the town of Sunde at the narrowing of Oldevatnet lake. Sundsreen drains down to the lake through Storelva river.



Map: Norge digitalt



Photo: Hallgeir Elvehøy (NVE, June 1996)



www.norgebilder.no (12.08.2004)

Events:

1697 – Ice avalanche, Glacier length change (advance). Sunde (Store-Sunde) in lower Oldedalen, a large farm at the narrowing of Oldevatnet, was one of the first farms which suffered damage from advancing Jostedalsbreen. The farm was destroyed by ice blocks falling from the edge of Sundsbreen glacier above the farm (Grove, 1988; Eide, 1955).

Monitoring: –

Future risks: None, unless the glacier changes substantially.

References: Eide, T.O., 1955. Breden og bygda. *Noreg Tidsskrift for folkelivsgransking*, Vol. 5, pp. 1–40.

Grove, J.M. 1988. The Little Ice Age. *Methuen, London and New York*, pp. 64–107.

NVE glacier database, Norge digitalt, www.norgebilder.no.

Supphellebreen (includes Flatbreen)

Location: Sogndal, Sogn & Fjordane.
Latitude: 61.53° N, Longitude: 6.8° E

WGI-ID: N4A000A8015

NVE-Atlas-ID: 2352

Dimensions: Area: 12.87 km², length: 8.4 km

Altitudinal range: 733 – 1734 m a.s.l.

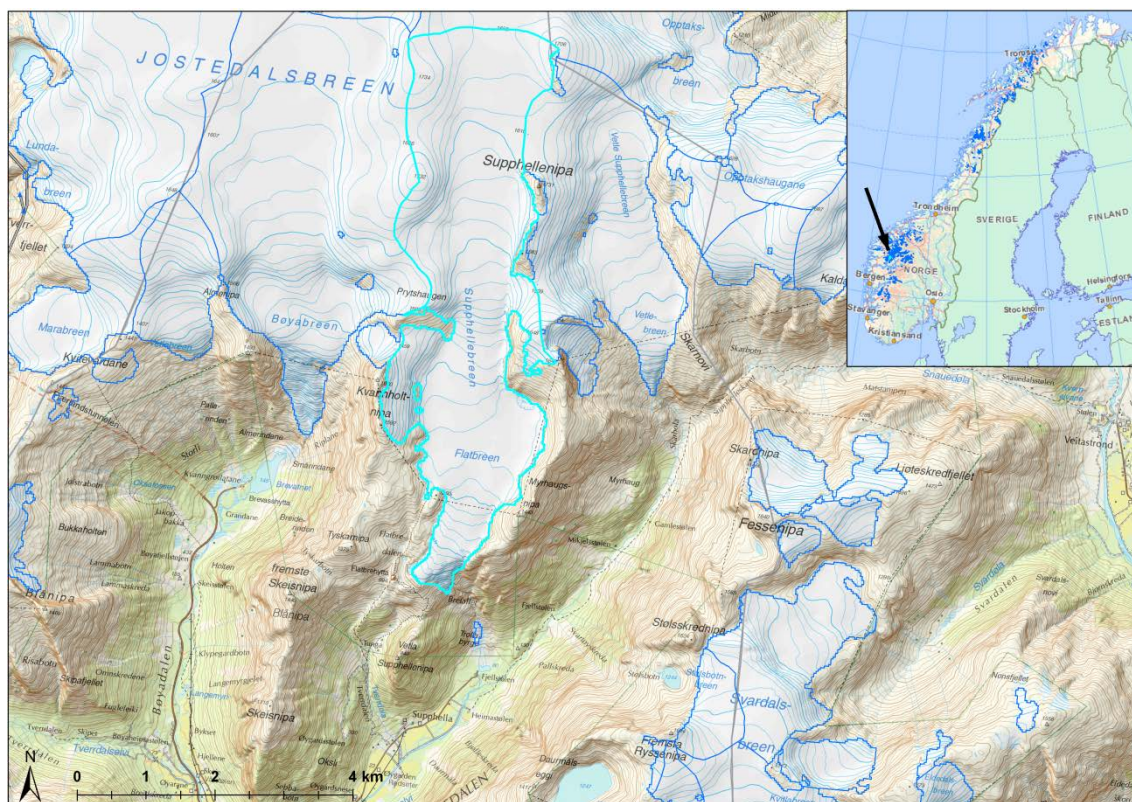
Glacier type: Outlet glacier

Event type: Jøkulhlaup, Debris flow

Description: One of the southern outlets from Jostedalsbreen ice cap in Fjærland. Supphellebreen is situated between Bøyabreen and Vetle Supphellebreen (Vetlebreen) glaciers.

The part of Supphellebreen which lies between Kvannholtnipa and Myrhaugsnipa mountains, is called Flatbreen glacier. Flatbreen can be seen from Fjærlandsfjorden and can be reached on foot. There is a cabin, Flatbrehytta, 300 metres from the glacier tongue.

Supphellebreen (together with Flatbreen) drains to Supphelle river in the valley of Supphelledalen. At the western side of Flatbreen's tongue, there is a lake dammed by a moraine ridge and the glacier.



Map: Norge digitalt

At the bottom of Supphelle valley, in front of Flatbreen glacier is a small glacier also called Supphellebreen. This glacier is at the lowest altitude of all the glaciers in Southern Norway, and is a regenerated glacier, "kept alive" by ice falling from the glacier above it. See also section 4.1, page 181.



Flatbreen tongue, small glacier dammed lake and moraine ridge photographed from helicopter on 16th October 2005. Photo: Miriam Jackson, NVE

Events:

18th century – Jøkulhlaup and debris flow. Øygard farm became abandoned due to this event. It is not known if this was due to fear of new slides or floods or because the boulders were too big and the volume too large to be removed, as they had no equipment to remove them and resume farming (Breien, 2005).

1924 – Jøkulhlaup and debris flow (Breien, 2005).

November 1947 – Jøkulhlaup and debris flow caused by a moraine ridge failure. Bridge over Tverrdøla and the 3 m high flood mitigation structures in Supphelledalen were damaged by rocks and water. A road was also damaged by the flow. The rocks carried were not as large as in 2004, but they were big enough that local residents had to use a bulldozer to remove them. The flow divided Tverrdøla river into two parts (Breien, 2005).



Maps: Norge digitalt (above – combined orthophotos taken on 16.09.2006 and 26.06.2008)

08/05/2004 – Jøkulhlaup. Debris flow and flood caused by failure in the mountainous glacial moraine ridge that dammed water from Flatbreen following a period of sudden high temperatures and intense rainfall. Erosion due to the debris flow was extreme; the mass volume growing with a factor of ten, from around 25 000 m³ to around 240 000 m³ (+/- 10 %) in less than an hour. The water volume involved in the incident is unknown, but is at least 50 000 m³. 250 000 m² of farmland were covered in debris (Breien et al., 2008).

Monitoring: After the event in 2004 there were fairly extensive scientific investigations of the glacier and lake. Monitoring, including field visits and photography, is now done on a regular basis.

Mass balance measurements in 1964-67, 1973-75, 1979-82.

Front position measurements 1899-1958, 1977-83 and from 1992.

Pictures taken regularly from 1890.

Future risks: Jøkulhlaup and debris flow.

References: Breien, H. 2005. On the dynamics of debris flows. Case study Fjærland, Western Norway – a debris flow triggered by a natural dam breach. *Master Thesis in Geosciences, University of Oslo*, June 2005.

Breien, H., F.V. De Blasio, A. Elverhøi and K. Høeg. 2008. Erosion and morphology of a debris flow caused by a glacier lake outburst flood, Western Norway. *Landslides* vol. 5 (3), pp. 271–280.

NVE glacier database, Norge digitalt.

Svartenutbreen / Folgefonni, Søndre (NØ)

(This name is unofficial and refers to the location of the glacier south-west of Svartenut mountain summit)

Location: Odda, Hordaland.
Latitude: 60.0° N, Longitude: 6.42° E

WGI-ID: N4A000AJ015

NVE-Atlas-ID: 3139

Dimensions: Area: 7.13 km², length: 4.2 km

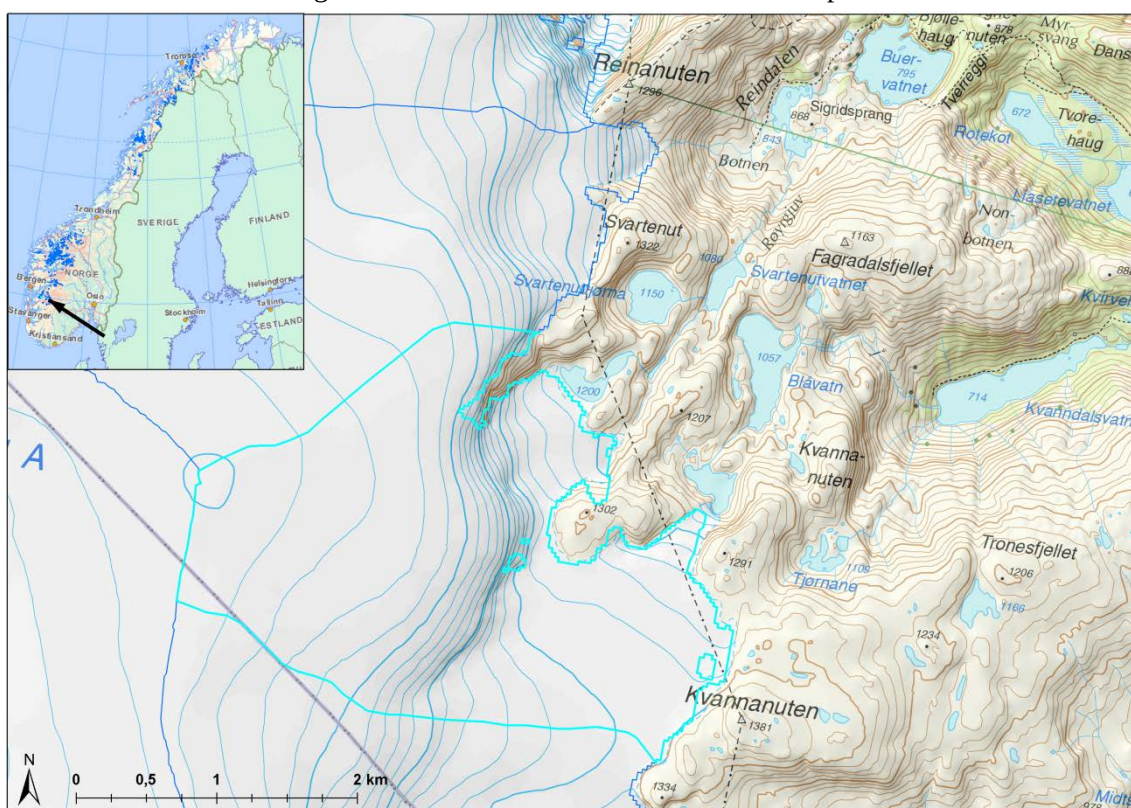
Altitudinal range: 1162 – 1602 m a.s.l.

Glacier type: Outlet glacier

Event type: Jøkulhlaup

Description: One of the eastern outlets from Søndre Folgefonna ice cap, situated north of Sauanutbreen glacier. The northern tongue of Svartenutbreen dams a lake at an elevation of 1200 m a.s.l. that is south of Svartenuten in Buerdalen. This is a relatively new lake: a map from 1957 shows that at that time the glacier covered the whole area.

In 1997, an inhabitant of Buer (Helge Buer) enquired about an assessment of the danger of flooding from this lake. A member of the Glacier and Snow Section at NVE (Hallgeir Elvehøy) surveyed the area in August 1997. At that time the lake was full and drained towards the northwest. There was a large wind hollow at the side of the hill that separated the



Map: Norge digitalt

glacier-dammed lake from the lake outlet, and the glacier ended in a relatively deep tarn.

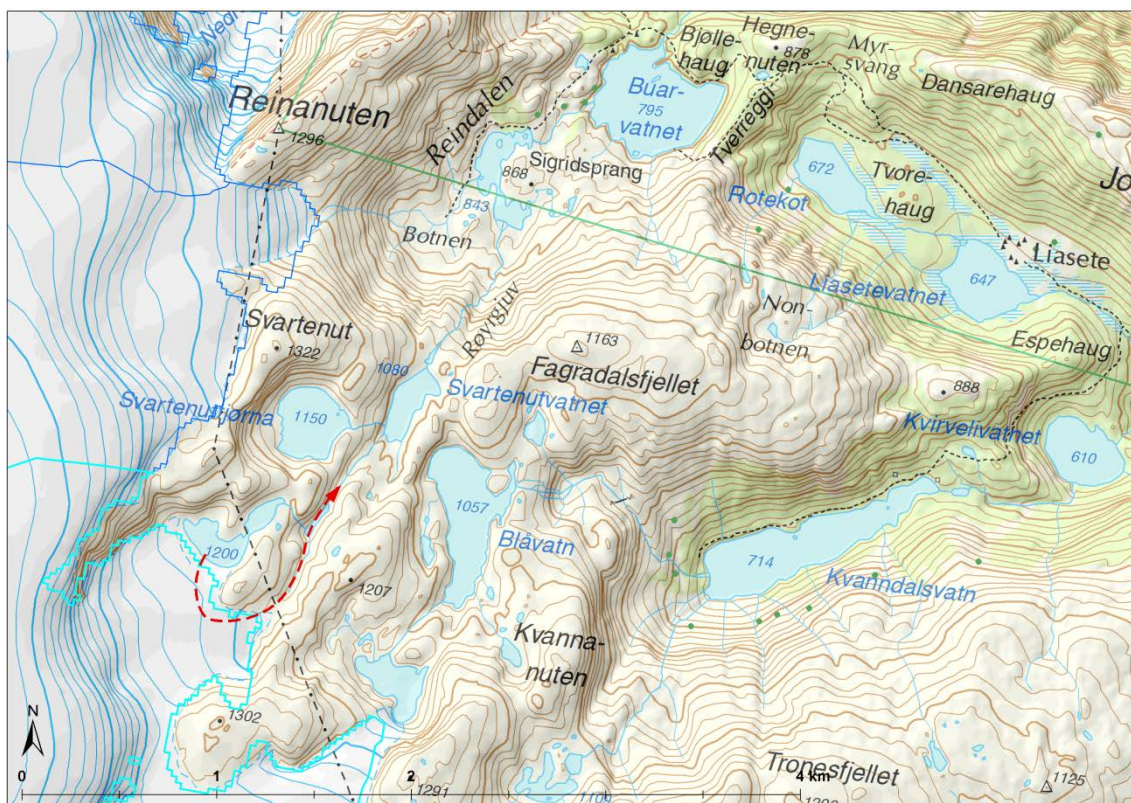
The lake usually drains directly to Svartenutvatnet lake. However, shortly before 9th October 2002 the water found its way under the glacier and the lake emptied. Increased water discharge was observed downstream.



Drained glacier dammed lake by the northern tongue of Svartenutbreen. Photo: Bjarne Kjølmoen (NVE, 10/08/2004)

Events:

August 2002 – Jøkulhlaup. On 9.10.2002 it was observed that the glacier-dammed lake south of Svartenuten mountain summit in Buerdalen valley was empty. The event probably took place some time during the summer, most probably August. Strandline altitude, water level and glacier altitude profile were measured. Estimated water volume: 1 mill. m³. Observations made on 20.09.2003 did not show changes in the lake's water level since October 2002 (Kjølmoen, 2004).



Map: Norge digitalt

Monitoring: Monitored by NVE. Pictures taken in 1997, 2002 and 2004.

Future risks: Jøkulhlaup.

References: Kjøllmoen, B. 2004. Jøkulhlaup sør for Svartenut. *Reiserapport 23/04*, NVE, seksjon HBM.

NVE glacier database, Norge digitalt.

Svartisen V (V)

Location: Meløy, Nordland.

Latitude: 66.72° N, Longitude: 13.99° E

WGI-ID: N4A000C4003

NVE-Atlas-ID: 1083

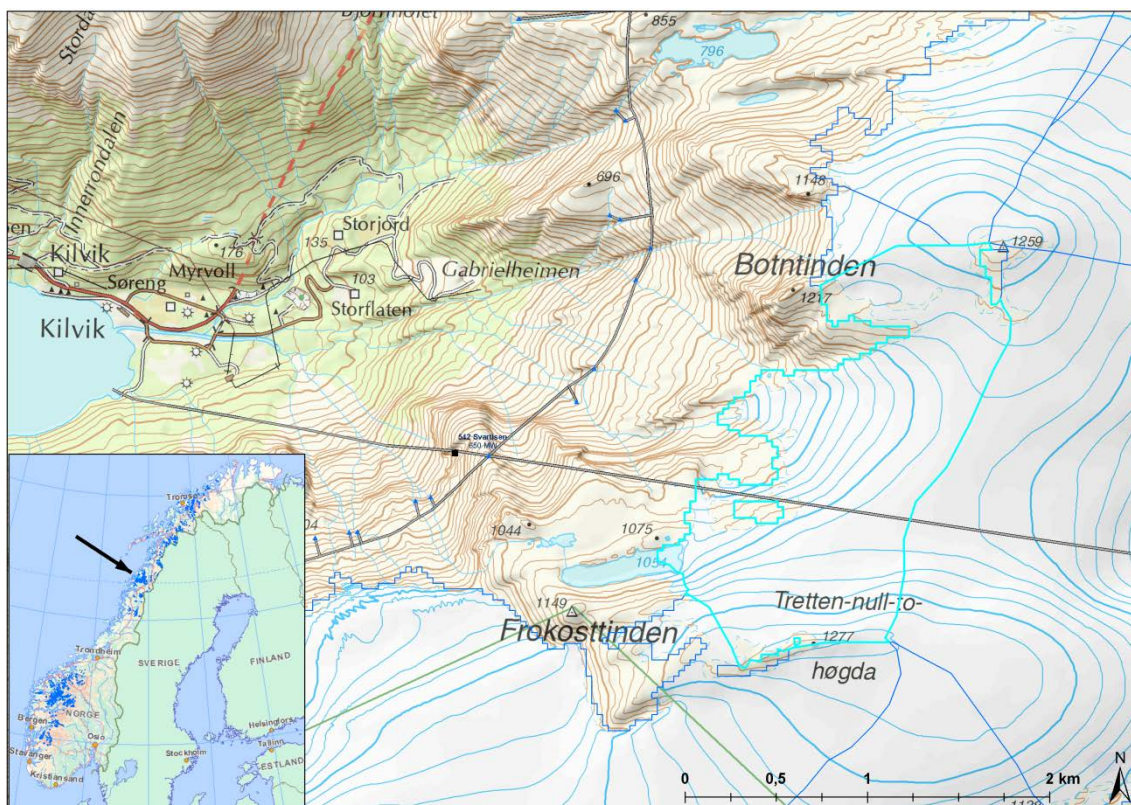
Dimensions: Area: 2.29 km², length: 1.9 km

Altitudinal range: 890 – 1273 m a.s.l.

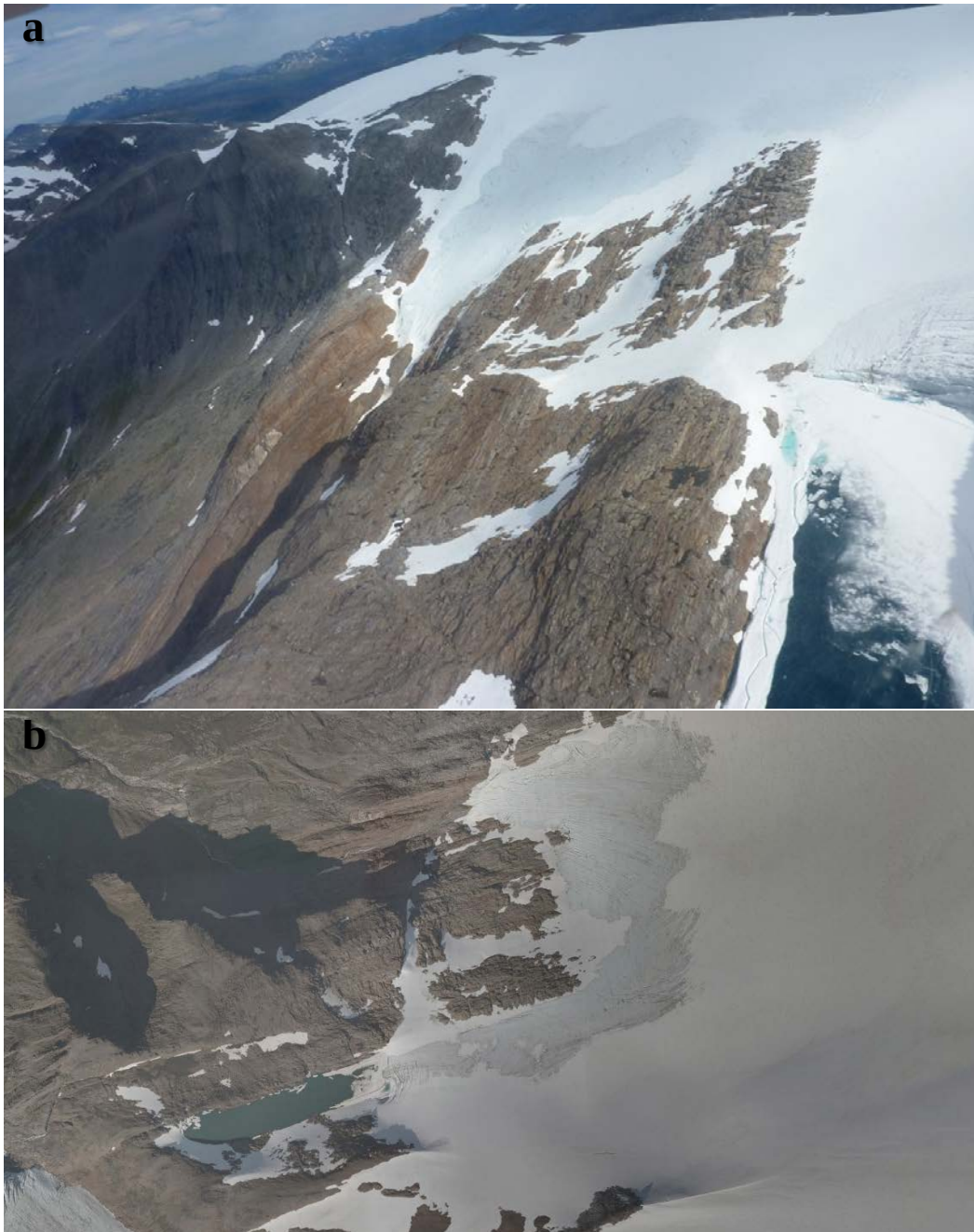
Glacier type: Outlet glacier

Event type: Potential jøkulhlaup

Description: One of the nameless northern outlets from Western Svartisen ice cap. It is situated on the western side of Tretten-null-to-breen glacier between Botntinden mountain to the north and Frokosttinden to the south-west. Svartisen V(V) drains to Holandsfjorden at Kilvik.



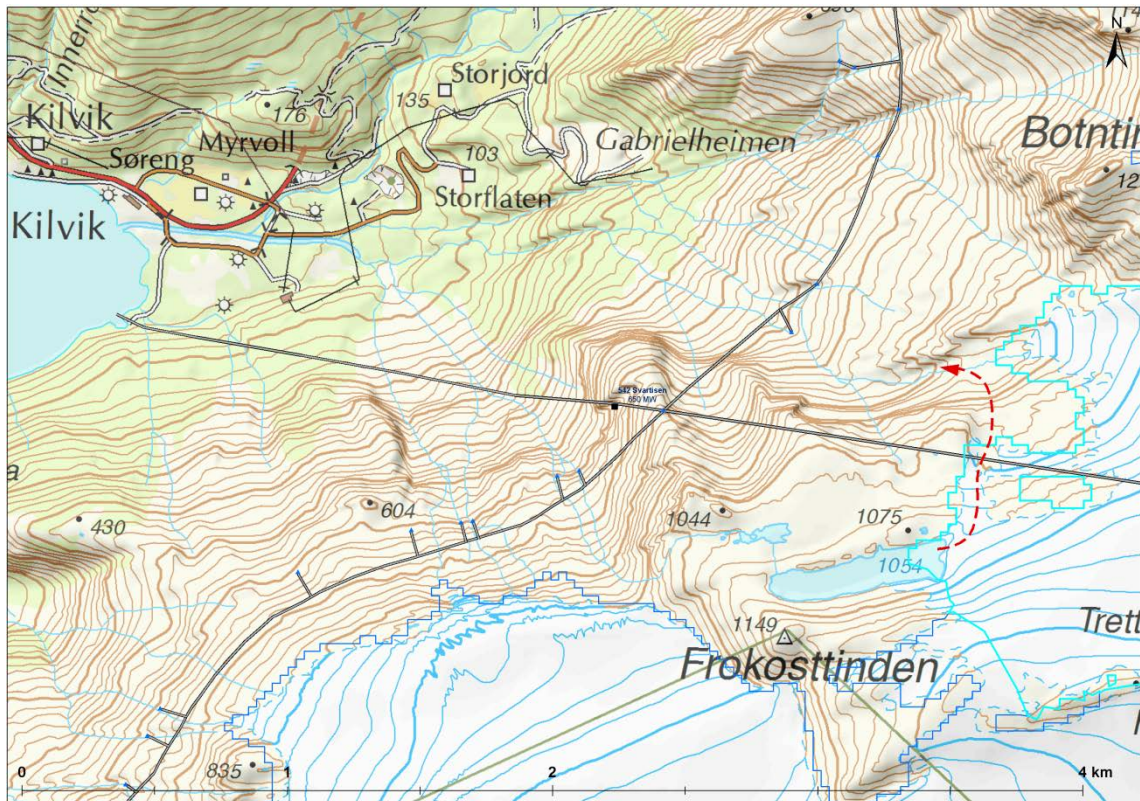
Map: Norge digitalt



a – Svartisen V (V) photographed from helicopter on 28th August 2012. Photo: Hallgeir Elvehøy, NVE

b – Svartisen V (V) from www.norgeibilder.no (24.08.2008)

On its south-west side the glacier dams a lake, which normally drains at its western end. However there is a possibility that the lake could drain under the glacier and down towards Kilvika, possibly affecting the transformer there or other infrastructure related to Svartisen hydropower station. The estimated volume of a flood is about 300 000 m³.



Map: Norge digitalt

Monitoring: –

Future risks: Jøkulhlaup.

References: NVE glacier database, Norge digitalt, www.norgebilder.no.

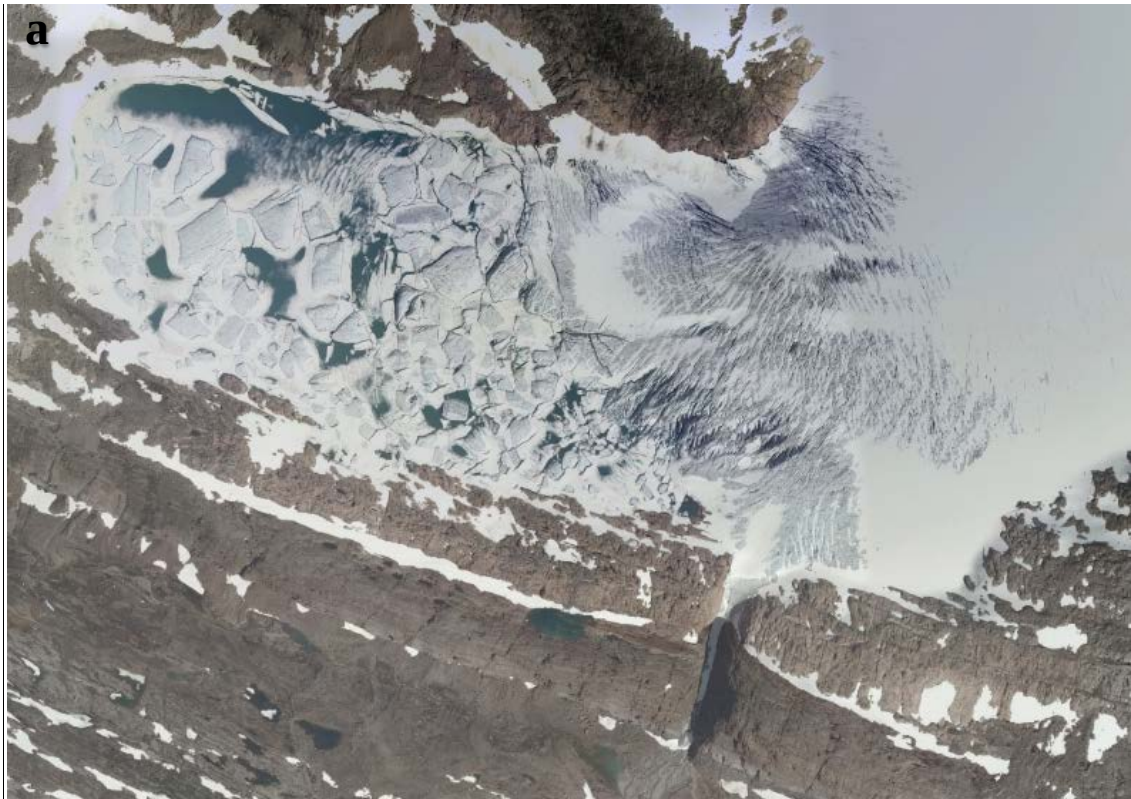
Svartisheibreen

Location:	Rødøy, Nordland. Latitude: 66.56° N, Longitude: 13.76° E
WGI-ID:	N4A000CX009
NVE-Atlas-ID:	1135
Dimensions:	Area: 5.62 km ² , length: 4 km
Altitudinal range:	686 – 1427 m a.s.l.
Glacier type:	Valley glacier
Event type:	Jøkulhlaup

Description: Svartisheibreen is a small valley glacier south-west of the western Svartisen ice cap that calves into a recently formed proglacial lake, Heiavatnet. Svartisheibreen stretches from Steintinden (1533 m a.s.l.) and Svartisheia (1471 m a.s.l.) down to lake Heiavatnet (774 m a.s.l.). There is a deep ravine (Slukta) about 400 m south-east of Heiavatnet along the mountain ridge. Run-off from the glacier drains both through lake Heiavatnet over the mountain ridge down to Slukta and under the ice down to Slukta, and further to the river Glomåga and lake Langvatnet in Rana.



Map: Norge digitalt



a – Svartisheibreen glacier tongue (www.norgeibilder.no (19.07.2008));

b – Svartisheibreen photographed from helicopter on 19th August 2002. Photo: Miriam Jackson, NVE.

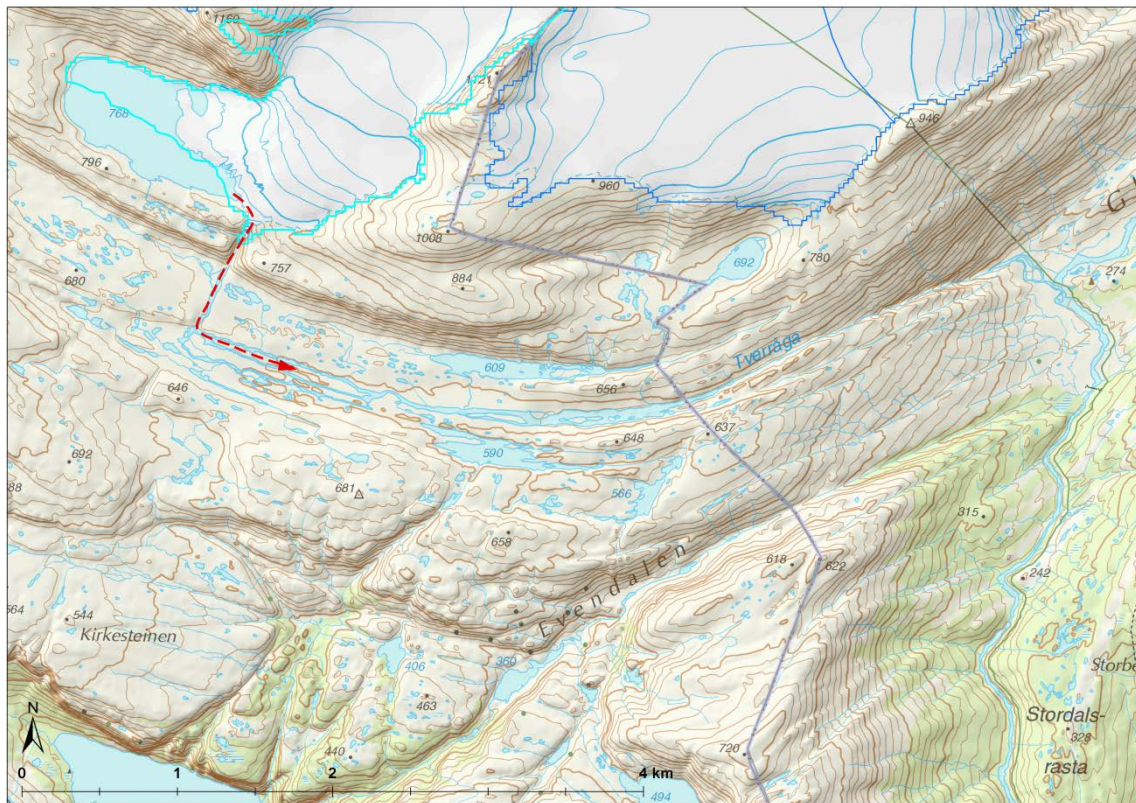
Events:

1989 – Jøkulhlaup from lake Heiavatnet. Low water level in Heiavatnet was observed in august 1989 and can be explained only by an outburst of the glacier-dammed lake (Kjøllmoen & Kennett, 1995).

7-15/04/1991 – Jøkulhlaup from lake Heiavatnet. Over eight days the water level of Heiavatnet sank 6 m (Kjøllmoen & Kennett, 1995).

1999 – Jøkulhlaup from lake Heiavatnet. Although no drainage channel was observed, the lake was dry and had clearly drained between 22nd September 1998 and 22nd September 1999, probably during the summer. This was probably the first jøkulhlaup from Heiavatnet since 1991 (Kjøllmoen et al., 2000).

Summer 2014 – Jøkulhlaup. Photographs taken from an aeroplane on 23rd September 2014 by Bjarne Kjøllmoen, NVE, show that the lake had recently drained, probably in late summer 2014. Photos taken in July 2013 show that the lake was then full.



Map: Norge digital. The red dashed line shows probably drainage route of water.

Monitoring: The glacier was monitored from 1987 in connection with a planned hydropower development (Kennett et al., 1997). After 1995 the monitoring programme was reduced to observations of lake level in Heiavatnet to see if jøkulhlaups occur, and observations of the snow line altitude in order to estimate annual net balance. In 2001 and 2002, Svartisheibreen was used as a test site in the EU-funded project OMEGA (Development of an Operational Monitoring

system for European Glacial Areas) in the 5th Framework Programme. The glacier is not presently monitored.

Mass balance measurements in 1988-94. Detailed map surveys in 1968, 1995 and 2001. Pictures have been taken regularly by NVE since 1968.

Future risks: Estimates made in 2000 (Kjøllmoen et al., 2000) suggested that at some point, the subglacial drainage tunnel would not close during winter, and lake Heiavatnet would drain permanently under the glacier towards Slukta. However there is still risk of jøkulhlaup.

References: Kennett, M., T. Laumann and B. Kjøllmoen. 1997. Predicted response of the calving glacier Svartiseibreen, Norway, and outbursts from it, to future changes in climate and lake level. *Annals of Glaciology*, Vol. 24, pp. 16–20.

Kjøllmoen, B., L.M. Andreassen, R.V. Engeset, H. Elvehøy and M. Jackson. 2003. Glaciological investigations in Norway in 2002. *NVE Report no 3*, 2003, 92p.

Kjøllmoen, B., L.M. Andreassen, H. Elvehøy, E. Gudevang and M. Jackson. 2001. Glaciological investigations in Norway in 2000. *NVE Report no 2*, 2001, 122p.

Kjøllmoen, B., L.M. Andreassen, H. Elvehøy and N. Haakensen. 2000. Glasiologiske undersøkelser i Norge 1999. *NVE-rapport nr. 2*, 2000.

Kjøllmoen, B. and M. Kennett. 1995. Breundersøkelser på Svartiseibreen 1988-94. *NVE-rapport nr. 17*, 1995.

NVE glacier database, Norge digitalt, www.norgebilder.no.

Svellnosbreen

Location: Lom, Oppland.
Latitude: 61.62° N, Longitude: 8.33° E

WGI-ID: N4A000AD023

NVE-Atlas-ID: 2622

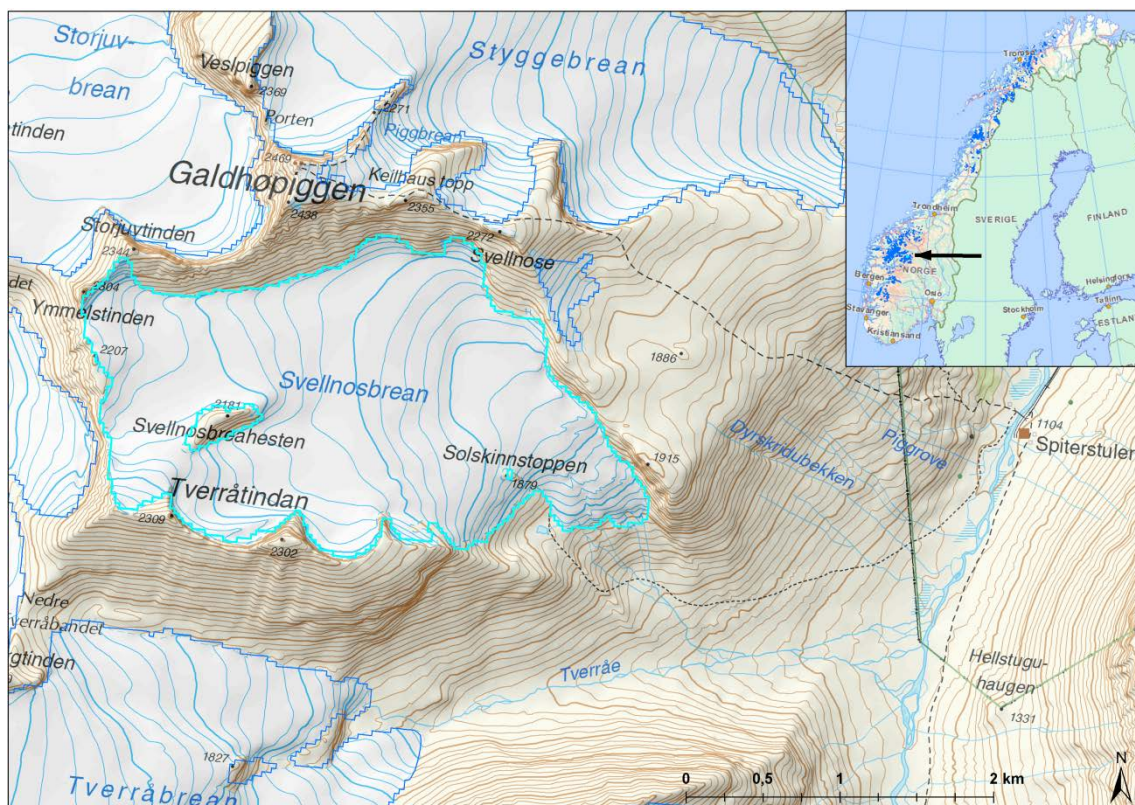
Dimensions: Area: 5.08 km², length: 4.4 km

Altitudinal range: 1580 – 2316 m a.s.l.

Glacier type: Mountain glacier

Event type: Mountaineering accident

Description: Central Jotunheimen, south of Norway's highest mountain peak Galdhøpiggen, 2469 m a.s.l. There are two nunataks on the glacier – Svellnosbreahesten (2181) and Solskinnstoppen (1879) – and a tourist path leading to the glacier from Spiterstulen tourist cabin in Visdalen valley, to which Svellnosbreen drains.



Map: Norge digitalt



Photo: Hilleborg K. Sorteberg (June 1999)

Events:

24/08/2012 – Mountaineering accident. During a glacier tour a 60 year old woman fell into a small (1 m deep and 1-1.5 m wide) crevasse when she attempted to jump over it. She landed on hard snow, almost icy, and broke her ankle. She was rescued by helicopter about 1.5 hours after the accident (Norges Klatreforbund).

Monitoring: –

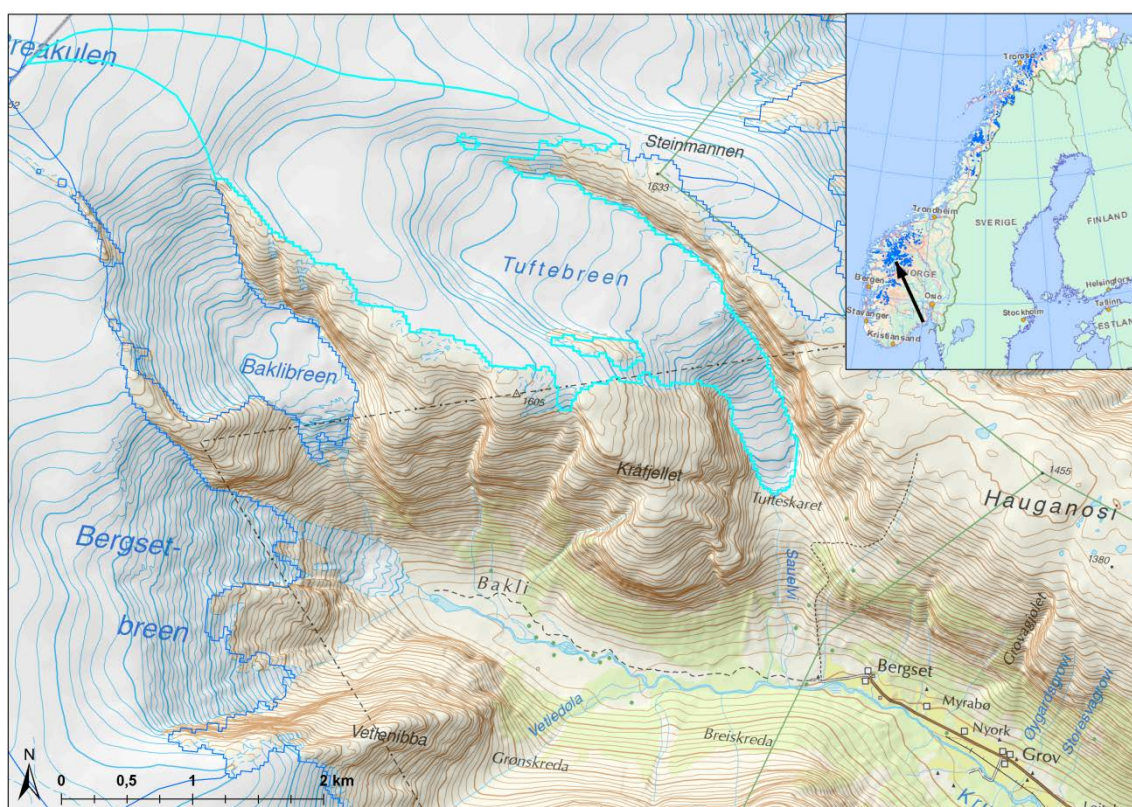
Future risks: Usual risks associated with glacier walking and climbing.

References: Norges Klatreforbund.

NVE glacier database, Norge digitalt, www.norgebilder.no.

Tuftebreen

Location:	Luster, Sogn & Fjordane. Latitude: 61.68° N, Longitude: 7.09° E
WGI-ID:	N4A000A4013
NVE-Atlas-ID:	2308
Dimensions:	Area: 6.79 km ² , length: 7.2 km
Altitudinal range:	799 – 1945 m a.s.l.
Glacier type:	Outlet glacier
Event type:	Ice avalanche, Glacier length change, Mountaineering accident
Description:	One of the eastern outlets from Jostedalsbreen ice cap, situated between Baklibreen and Nigardsbreen glaciers. Tuftebreen drains to Krundøla river in Krundalen valley through Sauelvi river, beginning at the glacier front in Tufteskaret rift in Bergsetdalen valley. Until the beginning of 20 th century Tuftebreen was called “Tverrbreen”, even though the rift in the mountainside where the glacier now terminates, has been called “Tufte-skaar” since at least 1742. The glacier is popular with tourists because it is easily accessible.



Map: Norge digitalt



Tuftebreen glacier tongue photographed on 15th August 2012. Photo: Hallgeir Elvehøy, NVE.

Events:

1684 – Glacier length change. High pastures used by two farmers, Knut Grov and Bergset, in the upper part of Krundalen valley were covered by advancing ice (Grove, 1988).

1741 – Glacier length change. The farm Bergseter, at the far end of Krundalen, was seriously damaged by the glacier (Eide, 1955; Tingbok for Indre Sogn, 1742).

14/07/2001 – Mountaineering accident. A 45-year old man fell into a crevasse, and was seriously injured (www.bt.no).

Monitoring: Glacier length change measurements from 2007. Photos taken in 1868, 1899, 1996, 1999, 2001-02, 2005, 2007-10, 2012.

Future risks: Usual risks associated with glacier walking and climbing.

References: www.bt.no

Eide, T.O., 1955. Breden og bygda. *Noreg Tidsskrift for folkelivsgransking*, Vol. 5, pp. 1-40.

Grove, J.M. 1988. The Little Ice Age. *Methuen, London and New York*, pp. 64-107.

Tingbok for Indre Sogn, 1742 – Avtaksforretningar i Jostedalen (1742). www.historielaget.jostedal.no

NVE glacier database, Norge digitalt.

Tunsbergdalsbreen

Location: Luster, Sogn & Fjordane.
Latitude: 61.65° N, Longitude: 7.0° E

WGI-ID: N4A000A4007

NVE-Atlas-ID: 2320

Dimensions: Area: 47.64 km², length: 19.5 km

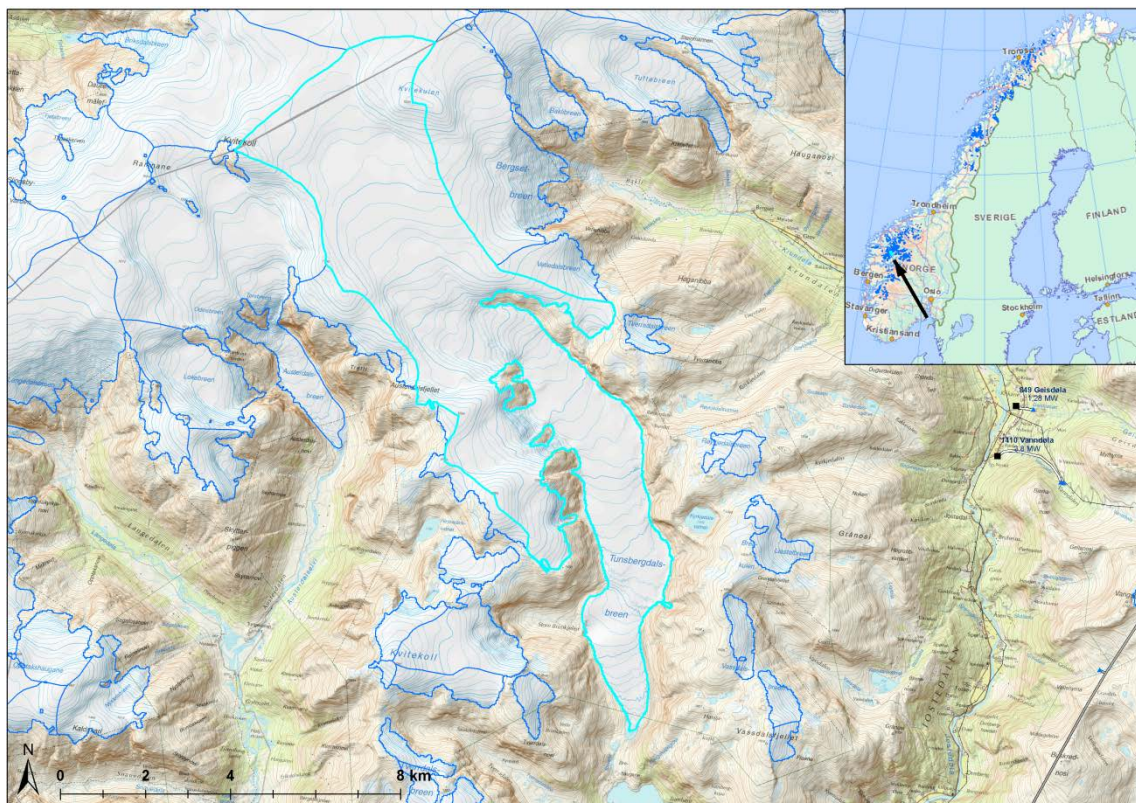
Altitudinal range: 656 – 1930 m a.s.l.

Glacier type: Outlet glacier

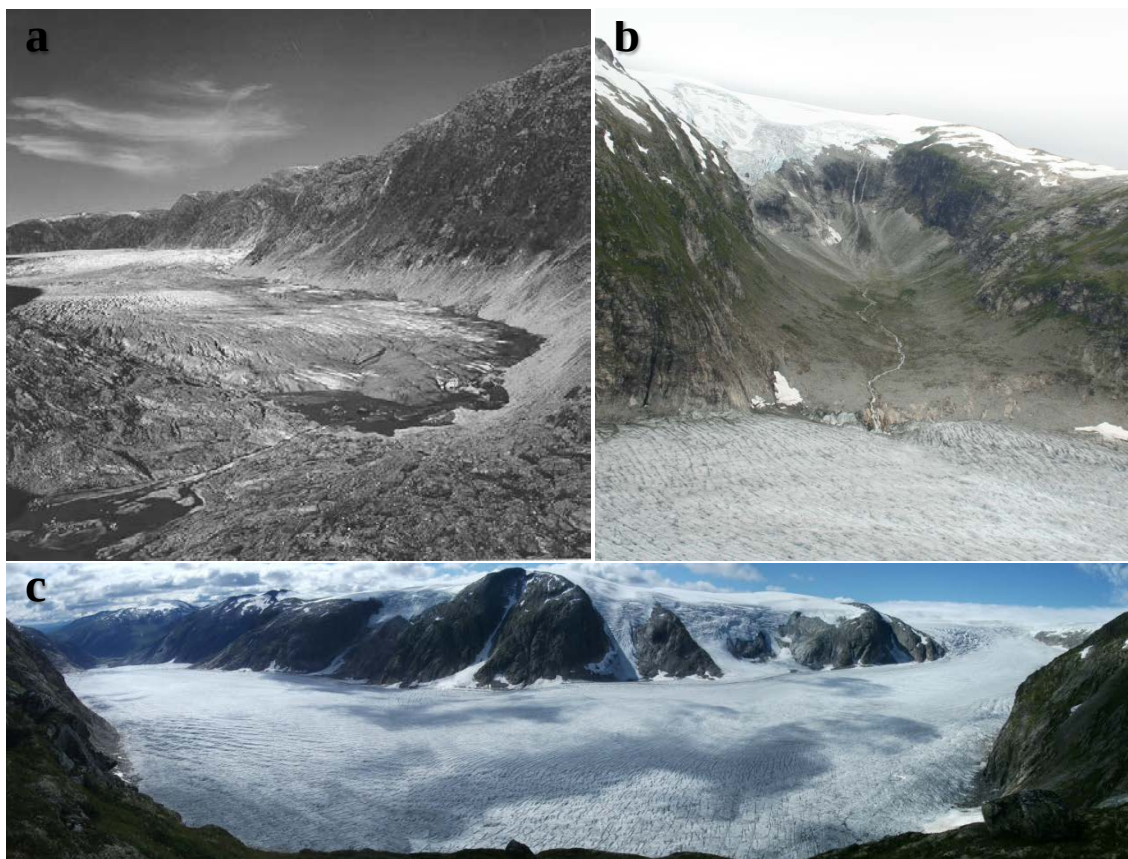
Event type: Jøkulhlaup

Description: One of the eastern outlets of Jostedalbreen ice cap, situated between Austerdalsbreen and Bergsetbreen glaciers. Tunsbergdalsbreen is the largest and the longest outlet glacier in southern Norway. It drains to the regulated lake Tunsbergdalsvatnet.

Former glacier dammed lake – now lateral supraglacial depression – Brimkjelen is located on the western side of the tongue.



Map: Norge digitalt



a – Tunsbergdalsbreen tongue on 23rd September 1998. Photo: Erik Roland;

b – Brimkjelen photographed on 19th August 2009. Photo: Hallgeir Elvehøy, NVE;

c – Panorama over Tunsbergdalsbreen in 2011, made by Morgan Gibson.

Events:

1896 – 1999 – Jøkulhlaups from Brimkjelen. Increased water discharge in river Leirdøla (Jostedalen).

Events in **July 1896, July 1897, July 1898, July 1899,**

August 1900 – a bridge more than 100 years old was swept away in a flood;

August 1903

14/08/1926 – 25-30 mill. m³; the river carried off enormous quantities of gravel from Leirdal valley, and built up a large gravel cone across the bottom of Jostedalen valley. This caused damming of the Jostedals river and inundation of a number of farms. Bridges, roads and forest destroyed (Eide, 1955);

21/06/1970, 11/08/1973 and in **1999**.

Monitoring: NVE started observations of Brimkjelen in 1997, and in the autumns 1997 and 1998 the lake was empty with no indication of the existence of a recent lake. Brimkjelen was observed again in 1999, and was also empty at this time. However, a circular crevasse pattern around the lake indicated that there had been water in the lake which had broken through the ice

dam prior to 29th July 1999. This outburst is the last one reported from Brimkjelen. NVE regularly photographs the depression and the river running into/under the glacier.

Mass balance measurements were performed on Tunsbergdalsbreen in 1966-72; front position measurements in 1900-1960 and from 2010; detailed map surveys in 1955 and 1964. Photos taken in 1900, 1903, 1907, 1977, 1979, 1982, 1998, 2000, 2004-2010.

Future risks: Due to the glacier thinning there seems to be no danger of jøkulhlaup under present conditions.

References: Eide, T.O., 1955. Breden og bygda. *Noreg Tidsskrift for folkelivsgransking*, Vol. 5, pp. 1–40.

Liestøl, O. 1956. Glacier Dammed Lakes in Norway. *Norsk geografisk tidsskrift* nr. 3-4. Bind XV, 1955-1956, h. 3-4.

Mottershead, D. N. and R. L. Collin. 1976. A study of glacier-dammed lakes over 75 years Brimkjelen southern Norway. *Journal Of Glaciology*, vol.17, Issue 77, pp. 491–505.

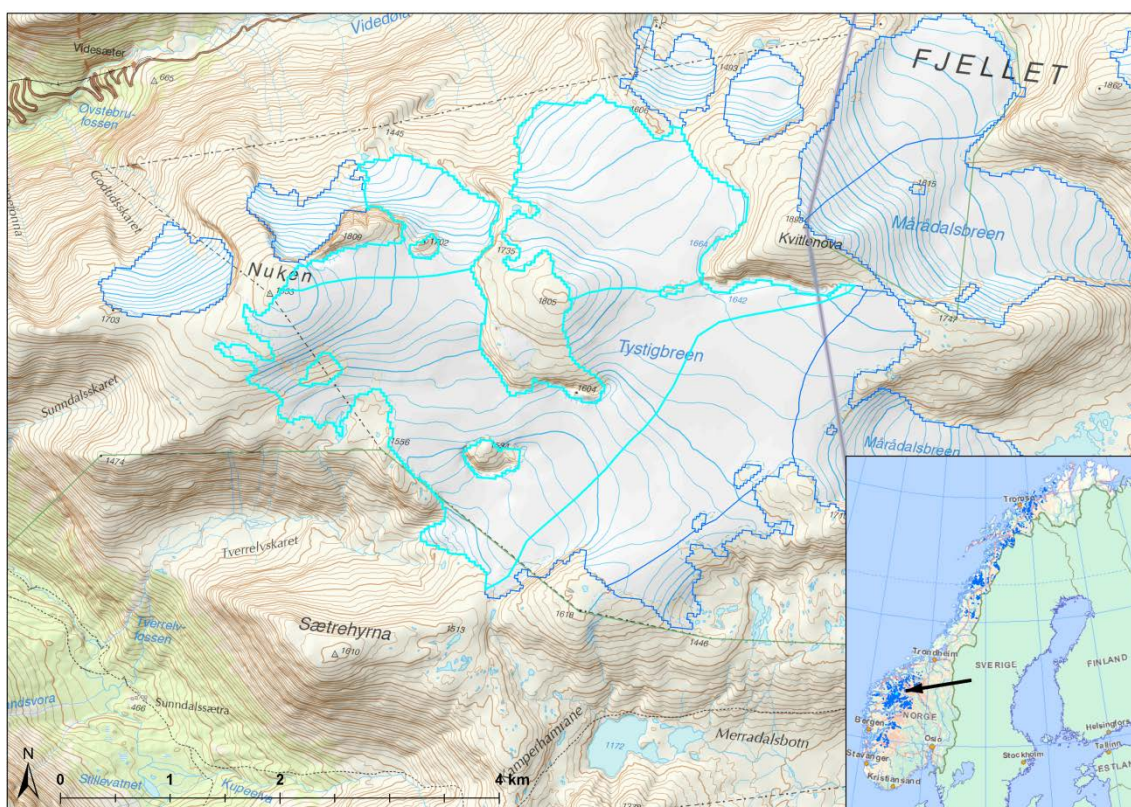
Vaksdal, M. and K. Melvold. Glacier Inventory in Norway. *Glaciorisk. EVG1 2000 00512*. Final report (2001-2003):

http://glaciorisk.grenoble.cemagref.fr/sec6_GLACIORISK_Other_Appendices.pdf

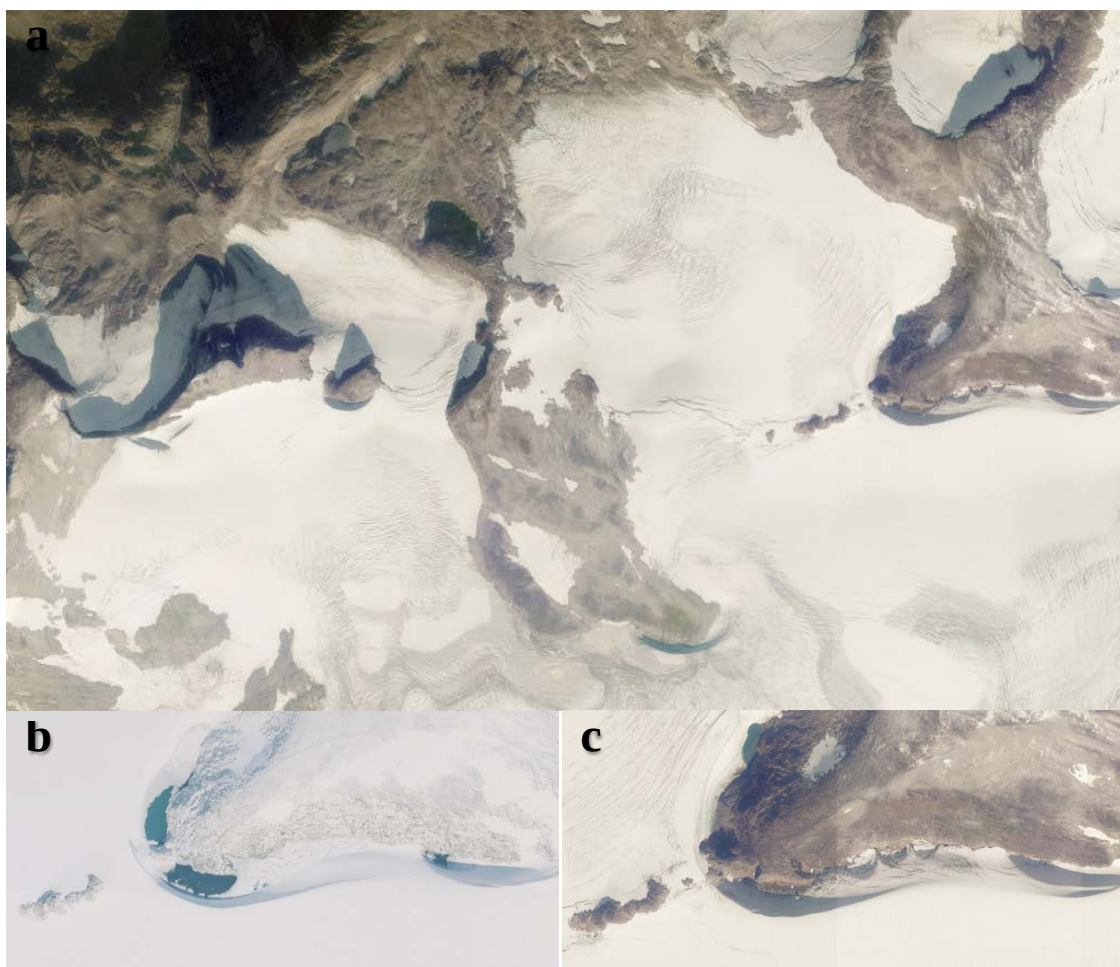
NVE glacier database, Norge digitalt.

Tystigbreen (N, NW and SW)

- Location:** Stryn, Sogn & Fjordane.
Latitude: 61.92° N, Longitude: 7.33° E
- WGI-ID:** N4A000BU019, N4A000BU018, N4A000BU022
- NVE-Atlas-ID:** 2428, 2429, 2435
- Dimensions:** Areas: 1.10, 2.77 and 5.97 km², lengths: 2.88, 2.11 and 3.86 km
- Altitudinal range:** 1288 – 1835 m a.s.l.
- Glacier type:** Outlet glaciers
- Event type:** Jøkulhlaup, Mountaineering accident
- Description:** Three outlet glaciers from Tystigbreen. The northern and north-western Tystigbreen glaciers drain to the river Videdøla in the valley Videdalen and further to the river Hjelledøla. South-western Tystigbreen glacier drains to the river Sunndøla through Tverrelvskaret. The rivers meet at the village of Grov and thence to lake Oppstrynsvatnet.



Map: Norge digitalt

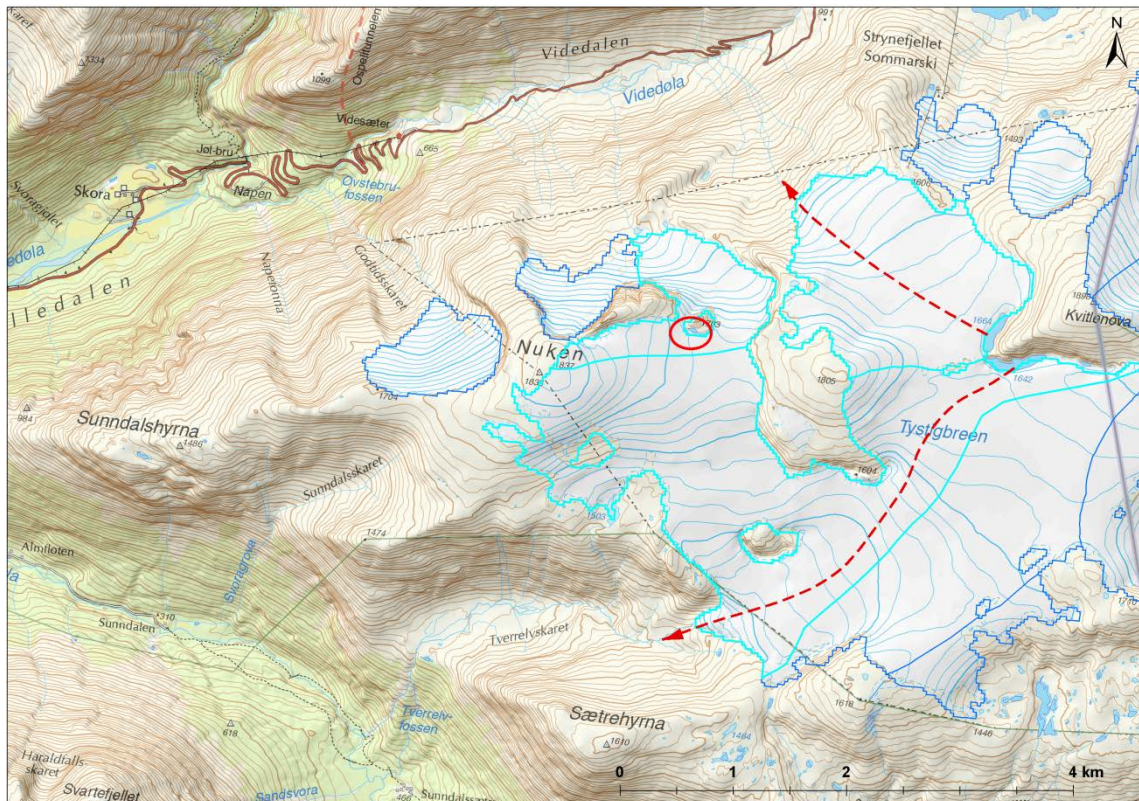


www.norgeibilder.no (**a** - 05.09.2010, **b** - 10.09.2005, **c** - 05.09.2010)

There are four glacier-dammed lakes on the updated digital map issued by the Norwegian Mapping Authority. These lakes are also visible on an orthophoto taken in September 2005 (www.norgeibilder.no, 2005; Photo **b**). However only three of them are visible in the orthophoto taken in September 2010 (www.norgeibilder.no, 2010; Photo **c**).

Two of the lakes are rather small: about 0.0017 and 0.0032 km² (www.norgeibilder.no, 2010; Photo **c**). It appears from the orthophotos that they increased in area between 2005 and 2010. However, it is difficult to say precisely because the 2005-photo was taken after a snowfall that covered the lakes.

The other two lakes had areas of 0.0298 km² and 0.0465 km² in September 2005 (www.norgeibilder.no, 2005; Photo **b**). However only one of these lakes is visible in the orthophoto from September 2010 (Photo **c**), and the estimate of the lake area is about 0.0043 km². It is thus possible that two jökulhlaups took place between September 2005 and 2010.



Map: Norge digital. Probable drainage routes from the two largest lakes are shown by the red-dashed lines.

Events:

Summer 1990 – Mountaineering accident (Tystigbreen (NW)). A 26-year old woman fell into a 7 m deep crevasse in the middle of Stryn Summer Ski Centre. She was rescued after an hour and had serious injuries (VG 10.01.2002).

August 2010 – Jøkulhlaup. As summer 2010 was warm with much ice melting and the lake to the right is completely dry on 2010-photo, it is most probable that the water drained in August 2010. These two lakes belong to different watersheds and drained in different directions. No flood was reported.

16/08/2014. Jøkulhlaup. Increased discharge was observed in the river Videdøla on 16th August by personnel at Videseter Hotel. It is probable that the most northeastern glacier-dammed lake drained under the glacier to the northwest and thence into the river Videdøla.



Increased discharge in river during jøkulhlaup. Photo: Ingolf Folven.

Future risks: Jøkulhaup. The glacier-dammed lake will probably continue to grow, and jøkulhlaups can become more frequent and larger. A flood could affect access to Stryn summer ski centre.

Monitoring: –

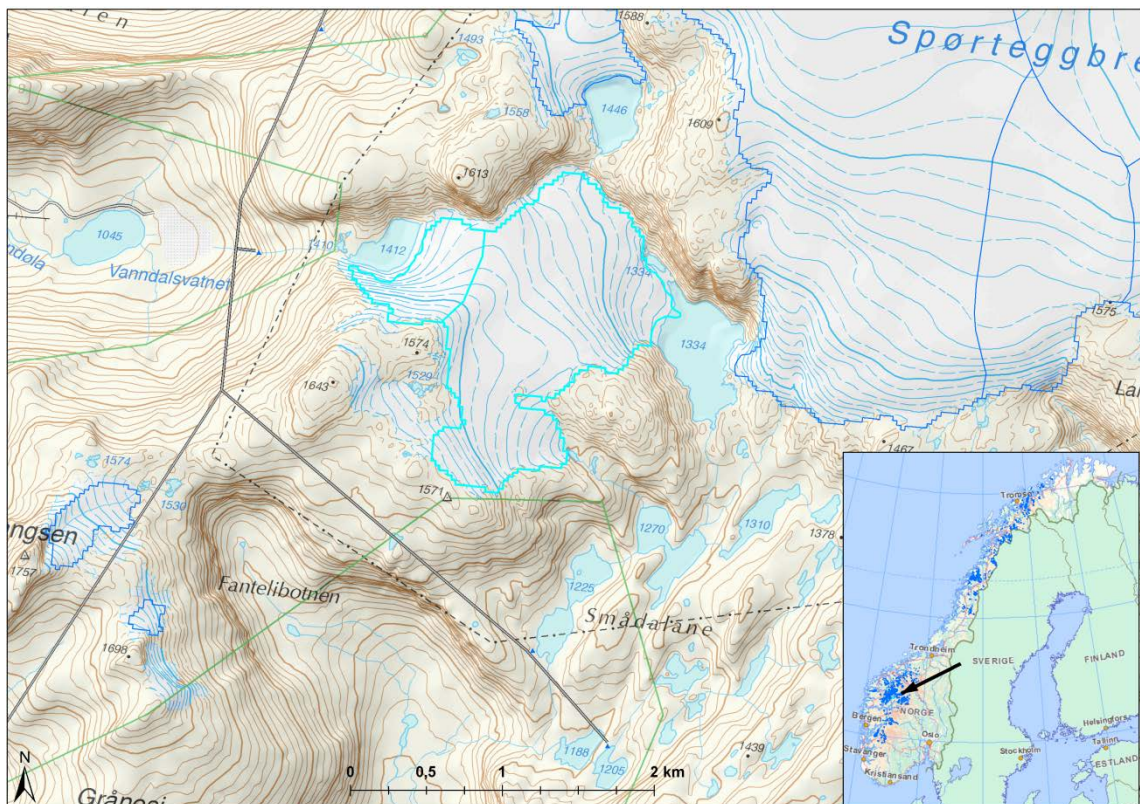
References: VG 10.01.2002
(<http://www.vg.no/nyheter/innenriks/artikkel.php?artid=7791302>)
NVE glacier database, Norge digitalt, www.norgebilder.no.

Vanndalsbreen

(This name is unofficial and refers to the location of the glacier close to Vanndalsvatnet lake in Vanndalen valley)

Location:	Luster, Sogn & Fjordane. Latitude: 61.59° N, Longitude: 7.41° E
WGI-ID:	N4A000A4028
NVE-Atlas-ID:	2531, 2532
Dimensions:	Area: 2.17 km ² , length: 1.8 km
Altitudinal range:	1336 – 1566 m a.s.l.
Glacier type:	Ice field
Event type:	Potential jøkulhlaup

Description: This glacier does not have an official name, but is locally known as Vanndalsbreen. It lies south-west of Spørteggbreen glacier, and was previously connected to it. The larger eastern part of it (1.9 km²) drains down to Smådalane. The western part (0.3 km²) dams a lake at an elevation of 1412 m a.s.l., which usually drains west to Vanndalsvatnet lake. According to Nesje et al. (2006), the part of Vanndalsbreen that drains to Vanndalsvatnet has existed continuously since ~ 1400 cal. yr BP.



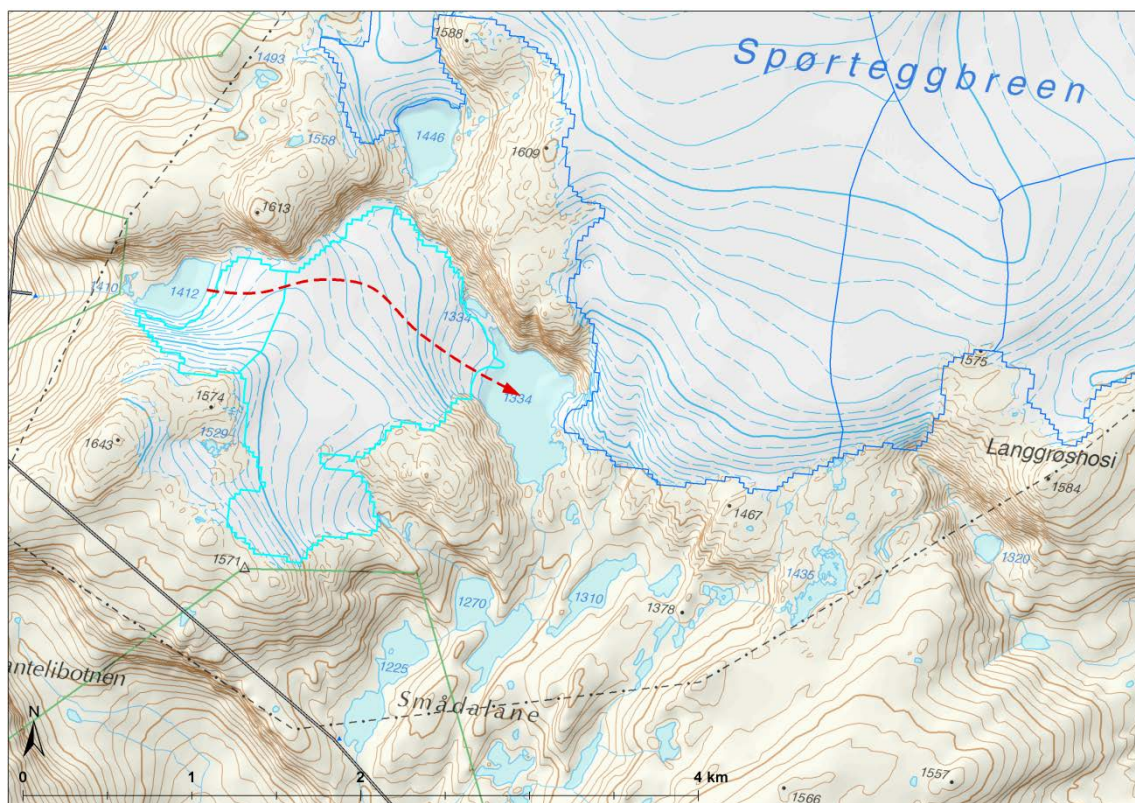
Map: Norge digitalt



Vanndalsbreen with the dammed lake on 30th August 2013. Photo: Even Loe (Statkraft AS)

Estimated volume is about 200 000 m³ of water.

The red, dashed line shows probable drainage channel in the event of a jøkulhlaup. It would probably not cause any damage.



Map: Norge digitalt

Monitoring: Statkraft AS.

Future risks: Jøkulhlaup.

References: NVE glacier database, Norge digitalt.

Vestre Memurubrean

Location: Lom, Oppland.

Latitude: 61.54° N, Longitude: 8.45° E

WGI-ID: N4A000AB031

NVE-Atlas-ID: 2772

Dimensions: Area: 8.58 km², length: 4.2 km

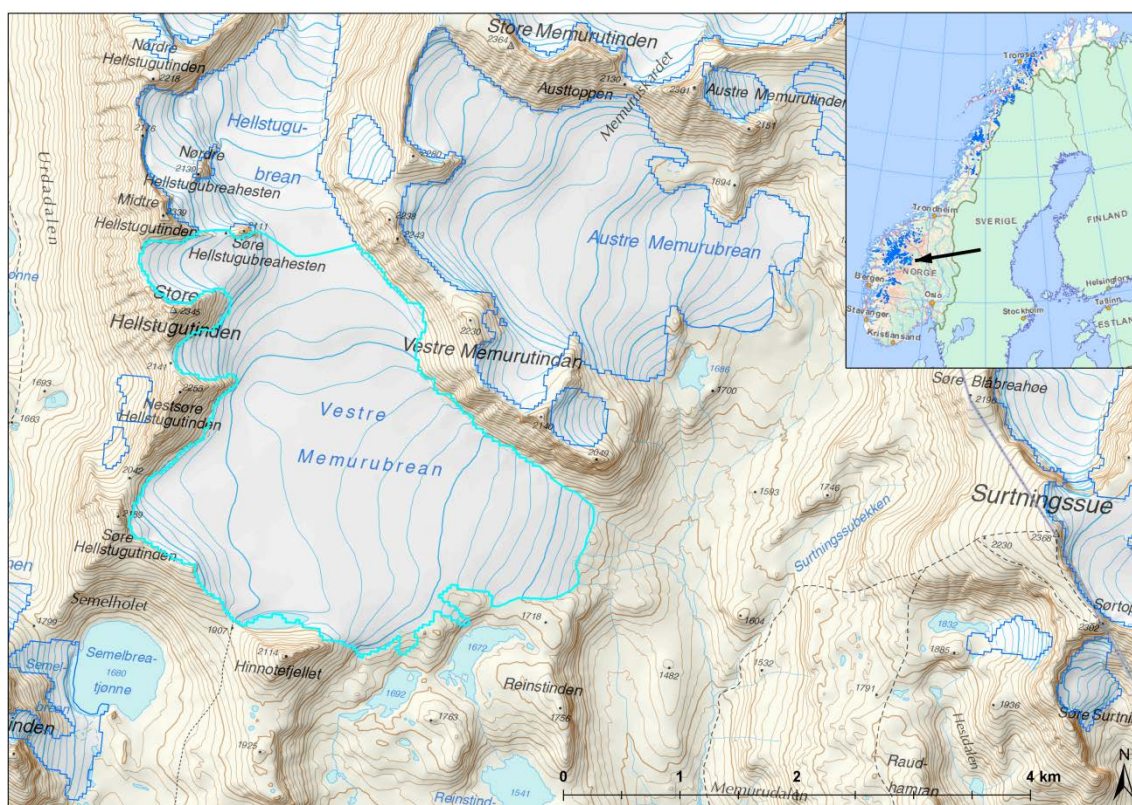
Altitudinal range: 1631 – 2229 m a.s.l.

Glacier type: Valley glacier

Event type: Potential jøkulhlaup

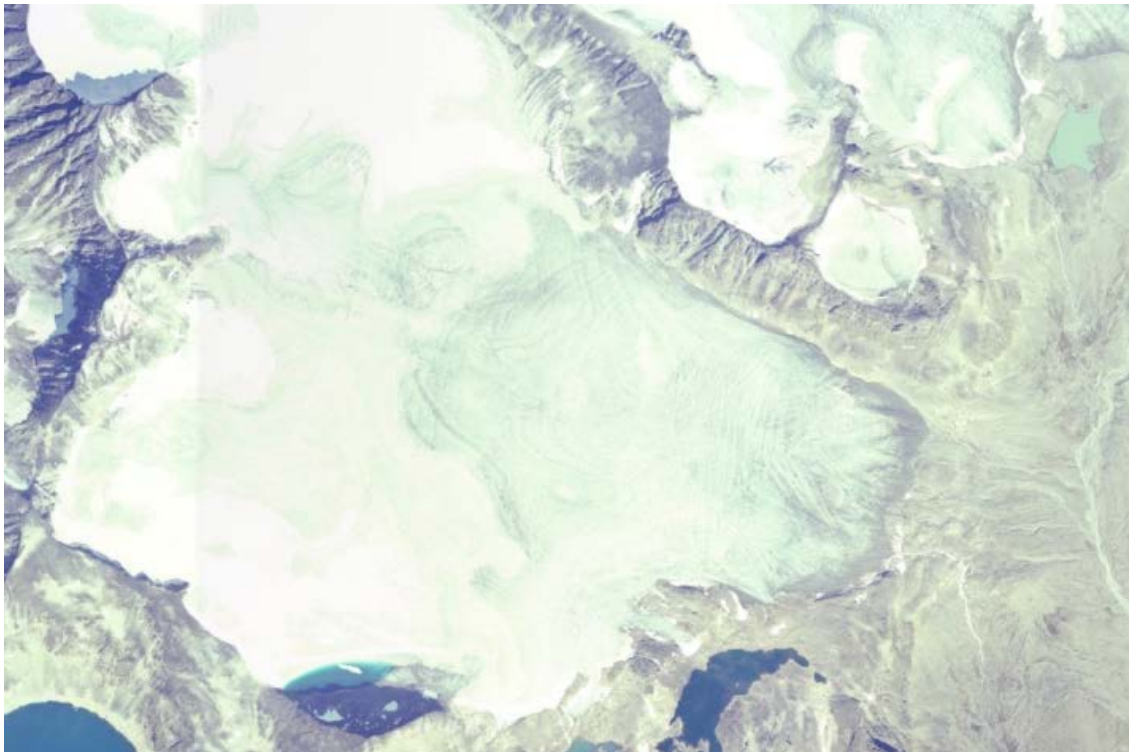
Description: The largest glacier in Eastern Jotunheimen. It is situated between Store Hellstugutinden mountain summit (2345 m a.s.l.) and Vestre Memurutindan glacier horn. Vestre Memurubrean drains south-east, and is connected to the glacier Hellstugubrean, which drains north.

On the northern side of Hinnotefjellet mountain (on the northern side of it) is a glacier-dammed lake with an area of about 0.056 km² (2004). The estimated volume is about 150 000 m³ of water.

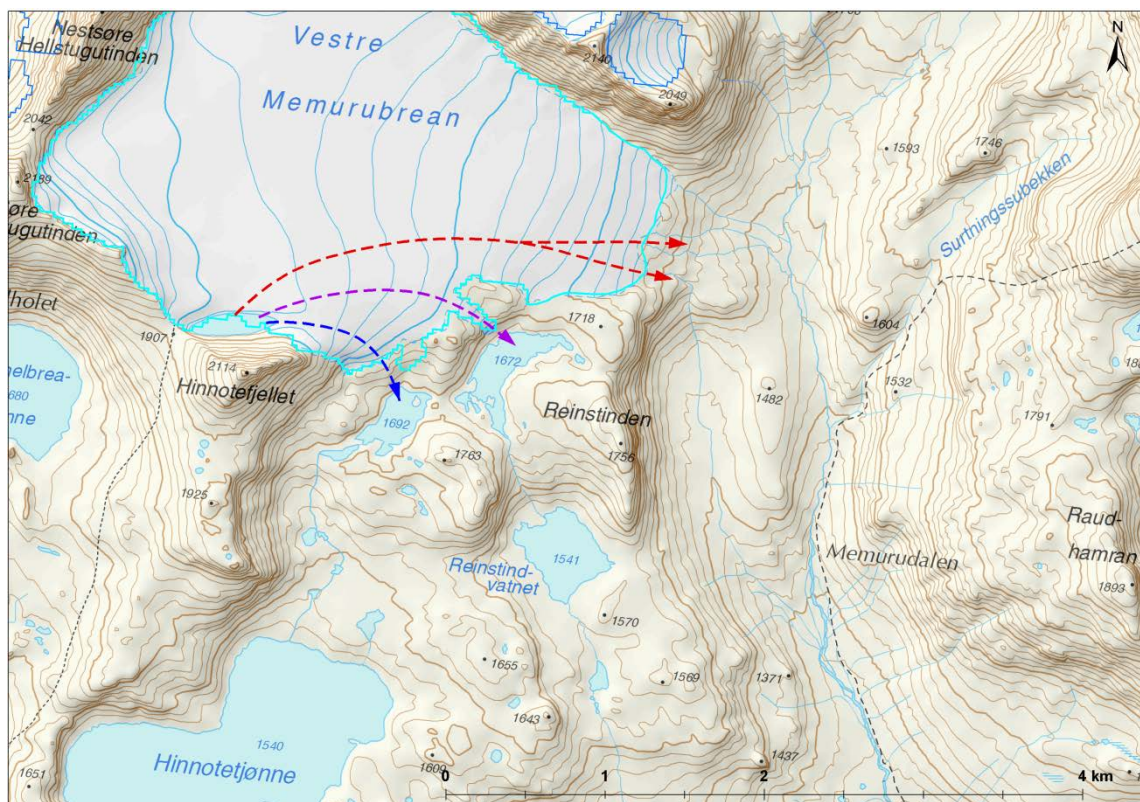


Map: Norge digitalt

Monitoring: Mass balance measurements in 1968-72. Detailed map surveys in 1966, 1997 and 2009.



www.norgebilder.no 12.08.2004



Map: Norge digitalt

Future risks: Jøkulhlaup.

References: NVE glacier database, Norge digitalt, www.norgebilder.no.

Vetledalsbreen

Location: Luster, Sogn & Fjordane.
Latitude: 61.63° N, Longitude: 7.08° E

WGI-ID: –

NVE-Atlas-ID: 2326

Dimensions: Area: 2.03 km², length: 2.3 km

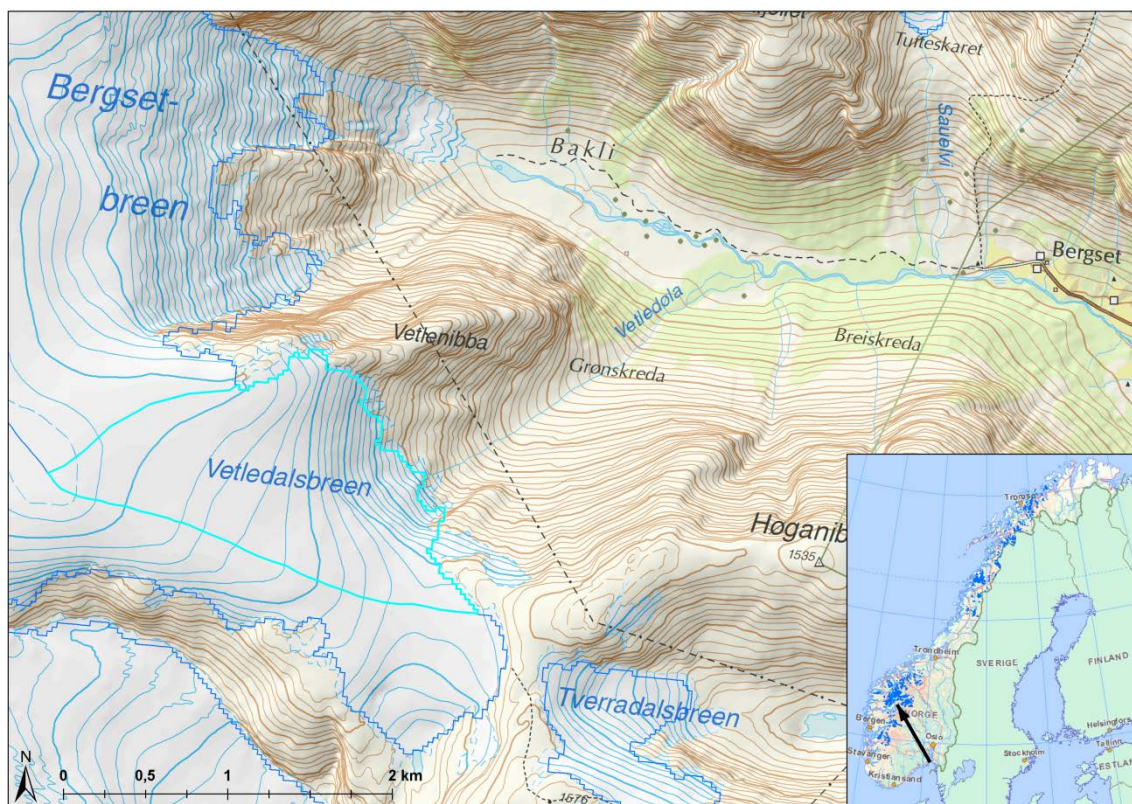
Altitudinal range: 1154 – 1633 m a.s.l.

Glacier type: Outlet glacier

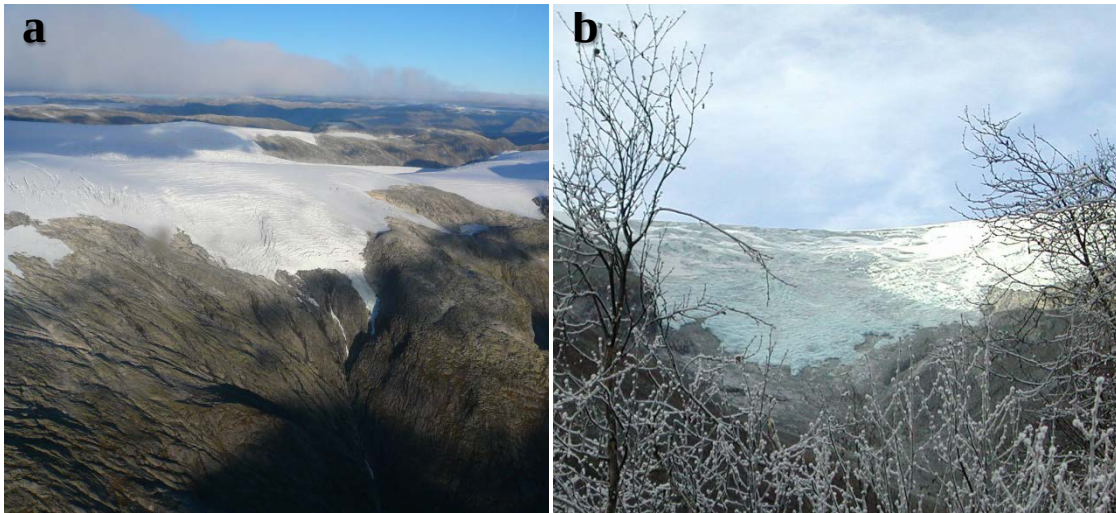
Event type: Glacier length change

Description: One of the eastern outlets from the central part of Jostedalsglaciens icecap. It is situated between Tunsbergdalsbreen and Bergsetbreen glaciers. Vetledalsbreen drains to Vetledøla river in Grønskreda and further to Krundøla river in Krundalen valley.

On old maps the glacier is called Grønskredbreen. However the name “Vetle-dals-breen” is documented as early as 1742 (lokalhistoriewiki.no).



Map: Norge digitalt



Vetledalsbreen: **a** – 11.10.2006, **b** – 20.10.2001. Photos: Miriam Jackson, NVE.

Events:

About 1743 – Glacier length change. Vetledalsbreen advanced between the mountains of Vetlenibba and Høganibba down to Krundalen valley, and joined with the advancing Bergsetbreen glacier. Part of Bergset farmland, including cattle enclosures and summer pasture, were almost completely destroyed by the combined glaciers (Grove, 1988).

Monitoring: Monitored by NVE. Photos taken in 1971-73, 1986, 1996, 2001, 2006 and 2009.

Future risks: –

References: Grove, J.M. 1988. The Little Ice Age. *Methuen, London and New York*, pp. 64-107.

Lokalhistoriewiki.no

NVE glacier database, Norge digitalt.

Vetlefjordbreen/Jostefonn (S)

Location: Balestrand, Sogn & Fjordane.
Latitude: 61.42° N, Longitude: 6.54° E

WGI-ID: N4A000A8009

NVE-Atlas-ID: 2148

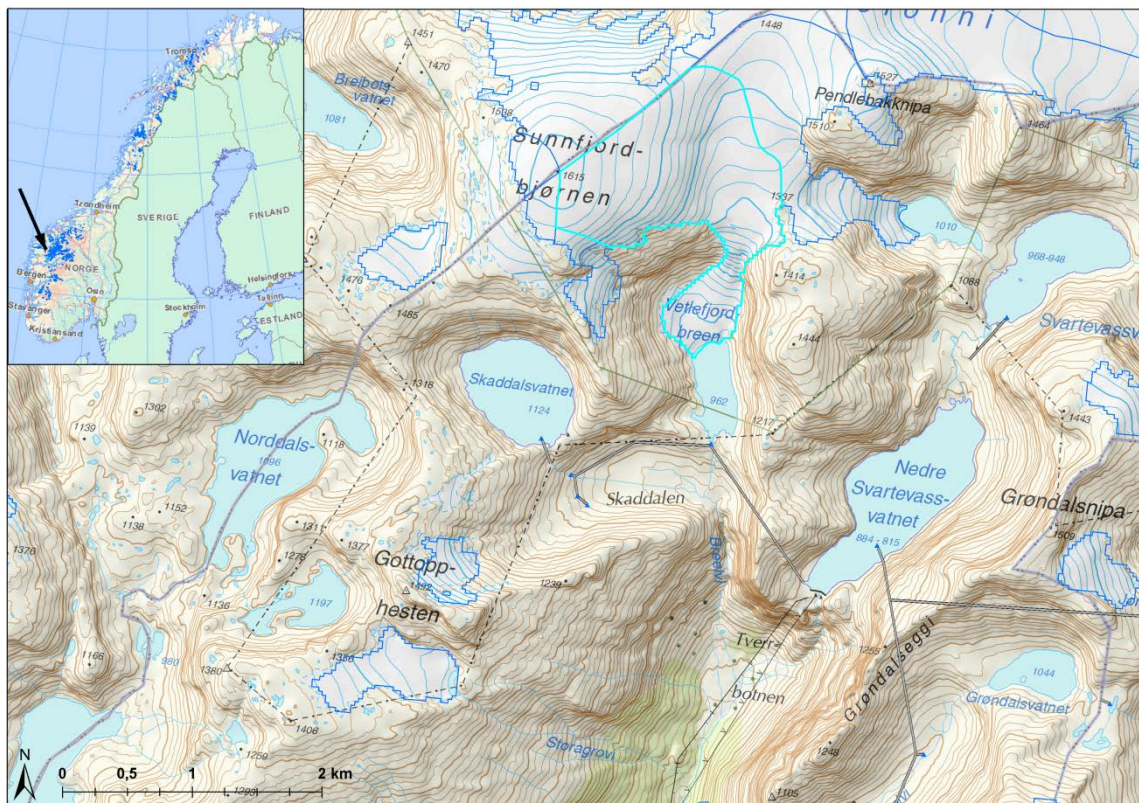
Dimensions: Area: 1.96 km², length: 2.8 km

Altitudinal range: 962 – 1613 m a.s.l.

Glacier type: Outlet glacier

Event type: Jøkulhlaup, Ice avalanche

Description: Vetlefjordbreen lies 15 km south of the southernmost part of Jostedalsbreen. Vetlefjordsdalen has an abrupt termination about 10 km from the head of the fjord. A steep gorge ascends from the valley towards the southernmost branch of Jostefonn, Vetlefjordbreen. West of the upper part of the gap there are two deep corries, one above the other. In the upper part is lake Skadevatn.



Map: Norge digitalt



Vetlefjordbreen on 28th July 1999. Photo: Hilleborg K. Sorteberg.

Events:

14/08/1741 – Jøkulhlaup. Extensive damage to farmland (Grove, 1988).

1741-42 – Ice avalanche (collapse of the glacier snout). From the front of Vetlefjordbreen's tongue a piece broke off between the two great rock-walls, with dimensions of approximately 78 m wide and 190 m long and of enormous thickness (Grove, 1988).

1820 – Jøkulhlaup from a glacier dammed lake downstream of Skadevatn, estimated volume was of order of magnitude 10 mill. m³. The flood ravaged farms and forests as it swept down the valley Vetlefjordsdalen (Liestøl, 1956).

1848 – Jøkulhlaup from a glacier-dammed lake downstream of Skadevatn, estimated volume was of order of magnitude 10 mill. m³. Farms devastated (De Seue, 1876; Liestøl, 1956).

Monitoring: –

Future risks: At present the tongue of Vetlefjordbreen glacier has greatly retreated past the mouth of the corrie and the lake itself no longer exists. There is thus no longer any danger of jøkulhlaup.

References: Grove, J.M. 1988. The Little Ice Age. *Methuen, London and New York*, pp. 64-107.

Liestøl, O. 1956. Glacier Dammed Lakes in Norway. *Norsk geografisk tidsskrift* nr. 3-4. Bind XV, 1955-1956, h. 3-4.

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NVE glacier database, Norge digitalt.

Vetle Supphellebreen / Vetlebreen

Location: Luster and Balestrand, Sogn & Fjordane.

Latitude: 61.53° N, Longitude: 6.84° E

WGI-ID: N4A000A5017

NVE-Atlas-ID: 2355

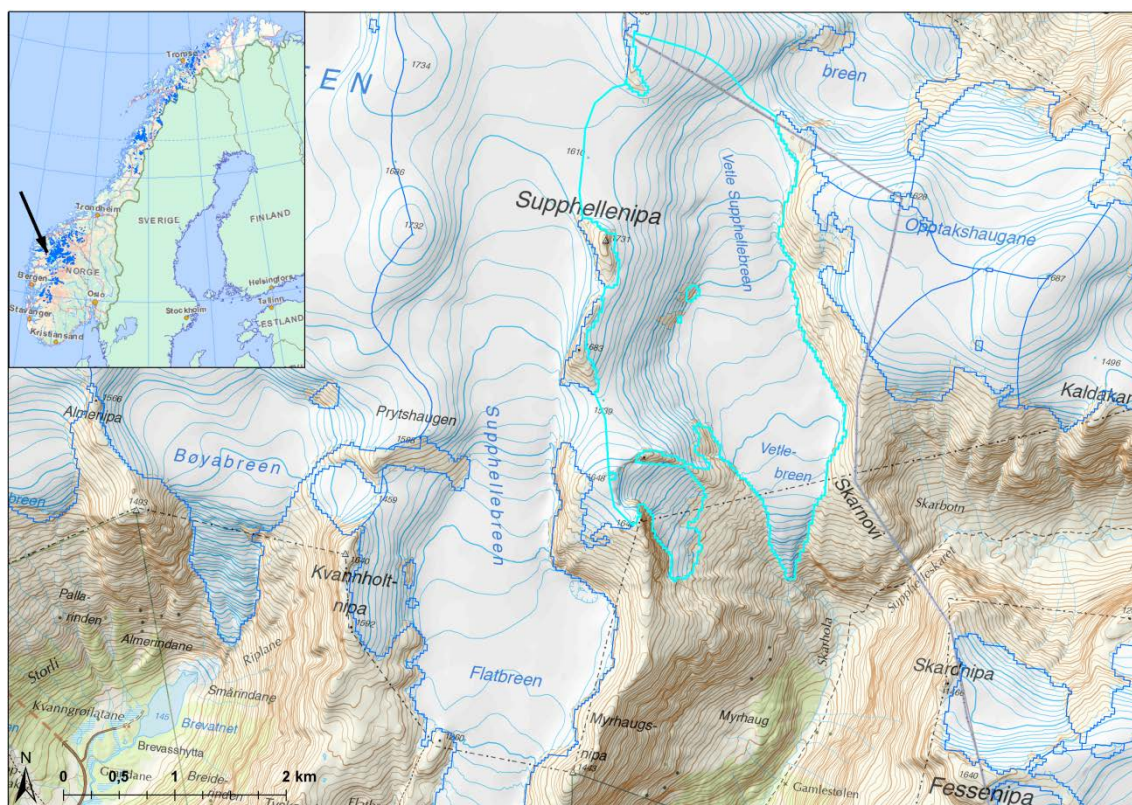
Dimensions: Area: 7.33 km², length: 5.4 km

Altitudinal range: 794 – 1706 m a.s.l.

Glacier type: Outlet glacier

Event type: Mountaineering accident

Description: One of the southern outlets from Jostedalsbreen ice cap, situated to the east of Supphellebreen glacier and north of Opptaksbreen glacier. The steep part of Vetle Supphellebreen's tongue is also called Vetlebreen glacier. The glacier drains to Supphelle river.



Map: Norge digitalt



Photo: Hallgeir Elvehøy (NVE, 11.08.2006)

Events:

14/07/2001 – Mountaineering accident. A moderately experienced person tripped in crampons and fell, then slid on hard ice. They fell 6 m down a steep slope, and then 3-4 m off an ice cliff and landed on a flat shelf. Result: broken rib, punctured lung, bruised (Norges Klatreforbund). It is not known if the accident happened on Vetle Supphellebreen or on one of the glaciers to the east.

Monitoring: Photos taken in 1884, 1899, 1903, 1908, 1998, 2004, 2006-07, 2011-12. Front position measurements by the Norwegian Glacier Museum (Norsk Bremuseum).

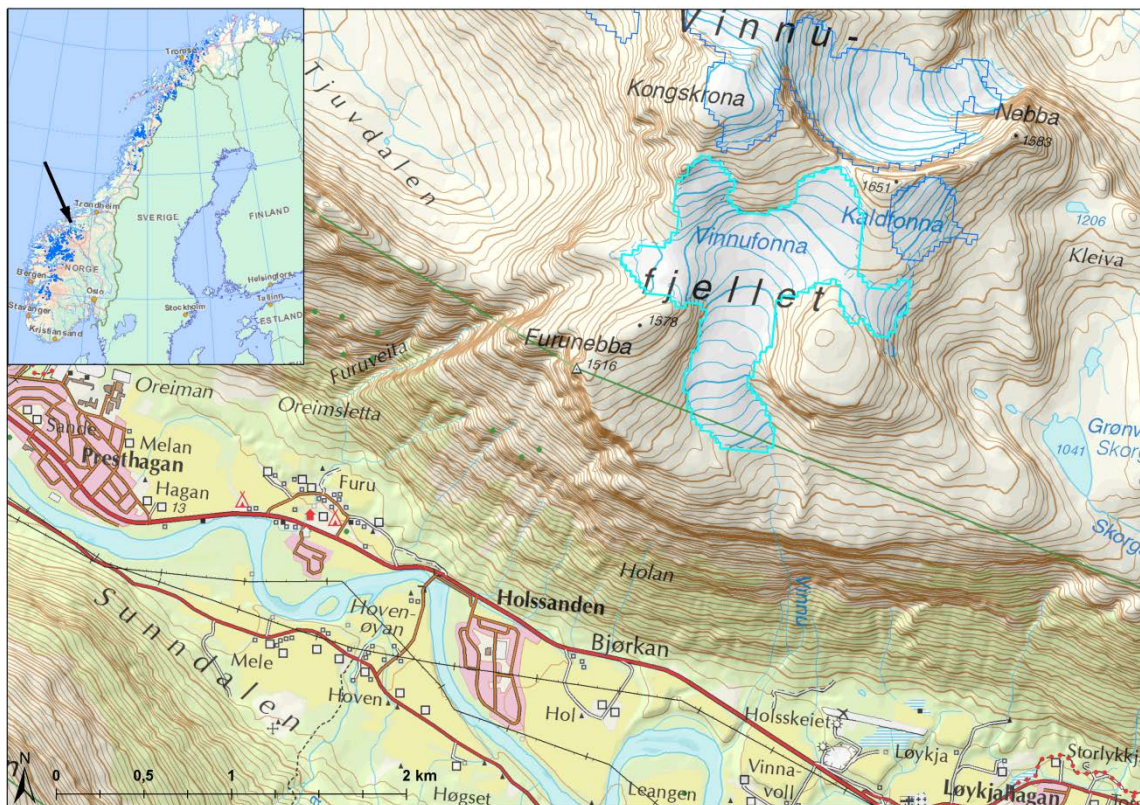
Future risks: The usual risks apply for glacier walking and ice climbing.

References: Norges Klatreforbund.
NVE glacier database, Norge digitalt.

Vinnufonna

Location:	Sunndal, Møre & Romsdal. Latitude: 62.68° N, Longitude: 8.66° E
WGI-ID:	N4A000CN001
NVE-Atlas-ID:	1601
Dimensions:	Area: 1.16 km ² , length: 1.9 km
Altitudinal range:	1169 – 1690 m a.s.l.
Glacier type:	Valley glacier
Event type:	Glacier length change, Ice avalanche

Description: Vinnufonna is a valley glacier in Vinnufjellet Mountains on the northern side of Sunndalen valley, Møre og Romsdal, a few kilometres northeast of Sunndalsøra town. There are several farms and other buildings in the valley below the glacier front. Vinnufonna drains to a small river, Vinnu, flowing to Driva river which eventually flows into Sunndalsfjorden fjord.



Map: Norge digitalt



www.norgebilder.no (22.09.2006)

Events:

1850 – Glacier length change. Vinnufjellet in Sunndal valley. Ice falling from glaciers.

Monitoring: –

Future risks: At present the glacier is too small for there to be an icefall.

References: NVE glacier database, Norge digitalt, www.norgebilder.no.

4 Specific events

Three glaciers where recent incidents have occurred are discussed in more detail. Two of the glaciers have experienced jøkulhlaups – Flatbreen has a moraine-dammed lake and Blåmannsisen has a glacier-dammed lake. At Baklibreen there was a major ice avalanche which caused several fatalities. These three glaciers and the most recent events are discussed here in more detail. For all incidents, NVE has been involved in monitoring the glacier.

A jøkulhlaup occurred in 2004 from Supphellebreen glacier in Fjærland and from Blåmannsisen in Nordland in 2001 from Blåmannsisen, with several more events at Blåmannsisen in succeeding years. The Fjærland jøkulhlaup triggered a 240 000 m³ debris flow. This caused extensive property damage but there were no injuries or loss of life. The jøkulhlaups from Blåmannsisen did not cause any injuries or loss of life either. Nor did they cause any material damage – on the contrary, the water drained into a reservoir for a hydropower plant and was thus economically beneficial.

The ice avalanche occurred from Baklibreen in Jostedal in 1986. Three foreign tourists were killed when several hundred thousand cubic metres of ice broke off from the glacier and fell to the valley bottom where they were walking.

4.1 Fjærland jøkulhlaup

A jøkulhlaup from Flatbreen glacier (lowermost part of Supphellebreen glacier) in May 2004 instigated a 240 000 m³ debris flow (Breien et al, 2008) and caused extensive damage. The event happened on 8th May in Fjærland, western Norway, after unseasonably warm weather and heavy rainfall.

The water came from a small lake at 1000 m a.s.l. that is dammed by Supphellebreen glacier, an outlet glacier from Jostedalsbreen, on one side and an arch-shaped end moraine on the other. The lake exists due to the retreat of the glacier from its maximum extent, the position of which is indicated by the moraine. Usually the lake drains under an ice fall later in the summer after the subglacial drainage has been developed. However, according to local residents the lake didn't drain in 2003, so lake level was higher than usual in 2004. Rainfall on 5th and 6th May 2004, followed by unseasonably high temperatures of over 12 °C by 8th May led to increased glacier and snow melting and a sudden increase of water into the lake. The large volume of water was able to breach the moraine and the lake water flooded out. The flood of water entrained a considerable amount of debris, which then caused considerable erosion as it proceeded down the steep valley Tverrdalen. The debris flow reached Supphelledalen, where the gradient abruptly becomes very flat, and was deposited on the farmland there and blocked the only road in and out of the valley. NVE anlegg spent several weeks clearing the debris.

A water volume in this event of 100 000 m³ or more is not unrealistic. Discharge from Flatbreen is not measured, but discharge is measured from nearby glacier Bøyabreen, and these data are

used here to study the order of magnitude of additional runoff from Flatbreen preceding the outburst. A hydrological station on the river Bøyumselv showed a sharp increase in discharge in the days directly preceding the event. This may be partly due to rainfall, as a total of 15 mm of rain was recorded in the area for 5th and 6th May. However, it is mainly due to a sharp increase in temperature that saw a rise from below 0°C in the early hours of 4th May, to over 12 °C by 8th May as recorded at Flatbreen, temperatures not usually seen until late in July. The rise in discharge closely followed the rise in temperature. Before the sudden increase in temperature, discharge was less than 4 m³/s. As the temperature increased, the discharge increased to a maximum of 18 m³/s. The extra volume of water in the river due to the warmer temperatures was over 2 million m³ over a 72 hour period from midday on 5th May to midday on 8th May (immediately before the jøkulhlaup). About 34% of the catchment area for this hydrological station is occupied by the glacier Bøyabreen. Hence, we can estimate that increased run-off from the glacier was responsible for about 740 000 m³.

Bøyabreen and Supphellebreen are similar glaciers – they have areas of 13.9 km² and 11.8 km² respectively, lengths of 5.7 km and 8.4 km, and elevation ranges from 490 – 1730 m a.s.l. and 720 – 1730 m a.s.l., hence we can expect that additional meltwater from Flatbreen (the lowermost part of Supphellebreen) into the lake before the outburst was also substantial. Not all the run-off from Supphellebreen drains towards the lake; much of it drains through Vetle Supphellebreen and into Supphelleelv further to the northeast. Although we cannot use the above rough calculation to give an accurate estimate of the extra water that was available for this flood either stored within the glacier or in the lake it demonstrates that there was a considerable increase in runoff volume, and that a water volume of 100 000 m³ or more is not unrealistic. Breien (2005) gives water volumes of 50 000 m³ to 500 000 m³ and a sediment volume of 100 000 m³ to 450 000 m³, with most likely volumes calculated as 100 000 m³ of water and 240 000 m³ of sediment (see also Breien et al, 2008).

There were probably previous events from this glacier. Local residents report a smaller event in 1947 (Breien, 2005), as well as previous events including one about 1926 and a substantial events in the 1700s.

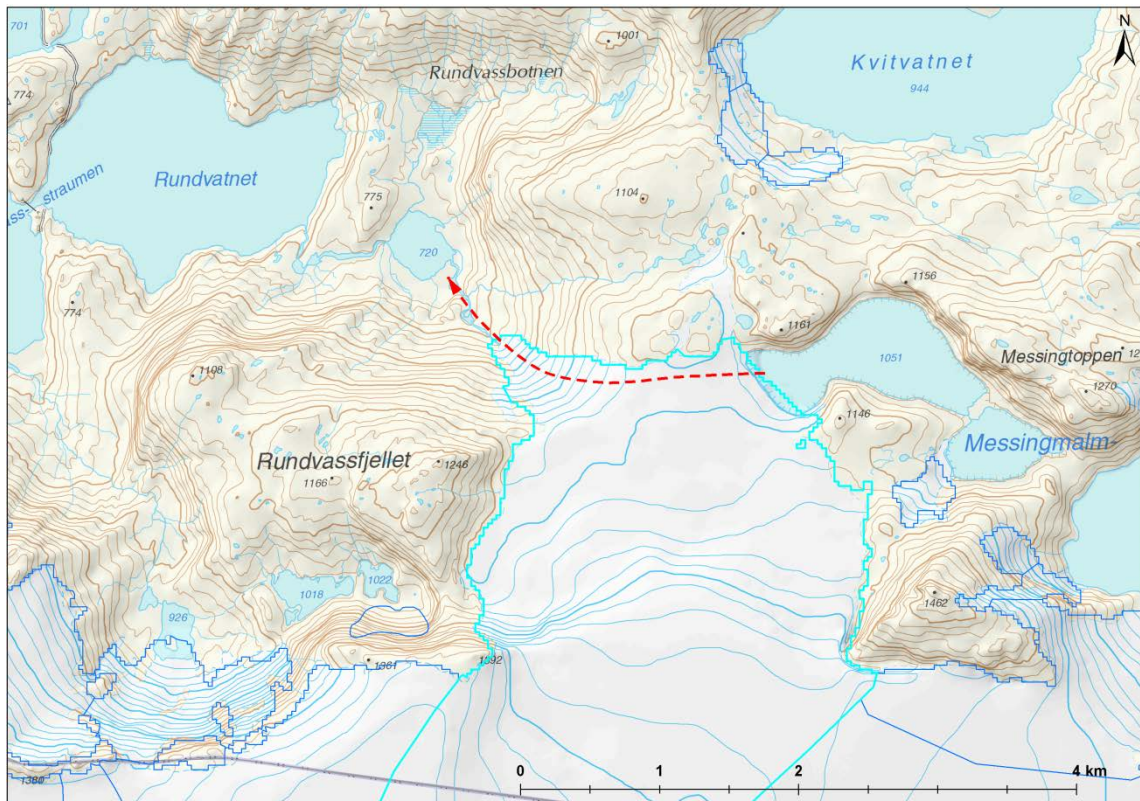


The breach through the moraine at Flatbreen. Note the figure standing in the middle of the channel for scale.
Photo: Hallgeir Elvehøy, NVE.

4.2 Blåmannsisen jøkulhlaups

The first known jøkulhlaup from Blåmannsisen occurred on 6th September 2001. 40 million cubic metres of water were released from an ice-dammed lake over the course of 35 hours. The jøkulhlaup was first detected when the water level in Elkem ASA's hydropower reservoir, Sisovatn, rose 2.4 m over a short period and apparently inexplicably. The water drained from an ice-dammed lake – upper Messingmalmvatn (usually called Vatn 1051), that normally drains east away from the glacier and over the border into Sweden. The jøkulhlaup drained almost the entire lake through a 4.5 km long tunnel under the glacier Rundvassbreen, and caused the lake level to fall by up to 50 m (Engeset, 2002).

Rundvassbreen is an 11.6 km² north-western outlet glacier from Blåmannsisen icecap in Nordland (see p. 117). The glacier was investigated in 2002 – 2004 and measurements included mass balance monitoring, glacier length change, glacier thickness and volume as well as water level of Vatn 1051 (Engeset (2002, 2003 and 2005), Kjølmoen et al. (2011). Mass balance measurements and other monitoring were re-initiated in 2011 (Kjølmoen 2012a,b and 2013).

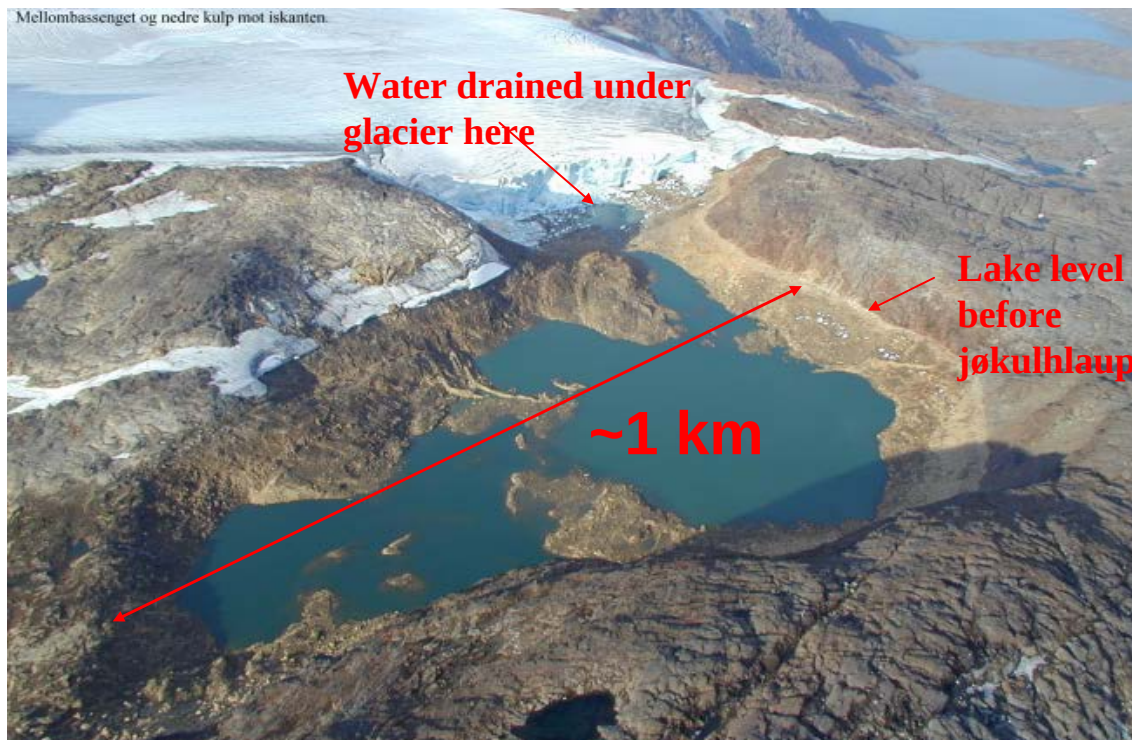


Map: Norge digitalt. The red dashed line shows the probable drainage path during a jökulhlaup.

Measurements of the surface elevation of the glacier show that it has thinned over recent decades, and the thickness has now apparently decreased enough that when conditions are appropriate the water drains under the glacier. According to Engeset (2002), by 2002 the glacier had thinned 15–30 m since 1961, with thinning greatest near Vatn 1051 and less along the centre of the outlet. Precise measurements with GPS showed that a significant part of these changes occurred between 1998 and 2002. The calving glacier front in Vatn 1051 retreated 300 m, causing the lake area to increase by 9%. A comparison of digital elevation models shows that the glacier was approximately in balance during the period 1961–1998, although the glacier thickened in the accumulation area and grew thinner and less extensive in the ablation area. Rundvassbreen continues to decrease in volume, the net mass balance was -0.78 m w.e./year on average during 2002–2004 and -1.13 m w.e./year during 2011–13 (Kjøllmoen, 2012a, b, 2013; table below). Total volume loss between 1961 and 2011 amounts to 172 mill. m^3 . The area of the glacier decreased from 12.11 km^2 in 1961 to 11.58 km^2 in 1998 and further to 10.94 km^2 in 2011 (Kjøllmoen, 2012b).

Year	Glacier net balance		ELA (m a.s.l.)	Front position change (m)
	Thickness (m w.e.)	Volume (mill. m ³)		
2002	-1.05	-	1320	-
2003	-1.07	-	1360	-
2004	-0.21	-	1260	-
2011	-1.6	-17	1405	-
2011-12	+0.6	+7	1180	+4
2012-13	-2.4	-27	>1525	-37

Vatn 1051 has a drainage area of 4.2 km² and a normal annual inflow of nearly 13 mill. m³. After the initial jøkulhlaup in 2001, the lake took three years to refill to its previous level, and water once again drained eastwards. It was not until late August 2005 (27th – 29th) that another jøkulhlaup occurred. There was heavy rainfall in the days preceding the jøkulhlaup, which may have triggered the event. During this second jøkulhlaup, 35 million cubic metres of water were released over a period of 36 hours.



The drained lake on 18th September 2001, 12 days after the first event. The water level before the jøkulhlaup is clearly visible. Photo: Hans Martin Hjemaas

The jøkulhlaups in 2001 and 2005 occurred when the lake was completely full. However, the jøkulhlaups in 2007 (29th August) and in 2009 (6th – 7th September) drained from a lake that was only half-full. The time between subsequent events decreased from 4 years to 2 years. The next jøkulhlaup occurred just a year later in September 2010 when the lake was less than half-full. Measurements of the glacier surface near the glacier-dammed lake showed a thinning

of 11 m between 2002 and 2009, and this continued presumably in 2010, allowing water to escape at a lower water level than previously (Kjølmoen et al., 2011).

Dates and volumes of jøkulhlaups from Rundvassbreen (based on Kjølmoen et al. (2011), Kjølmoen (2012a,b) and personal communication Hans Martin Hjemaas).

Year	Approximate dates	Water volume	Water level before event
2001	5 th – 7 th September	40 mill. m ³	Full
2005	27 th – 29 th August	35 mill. m ³	Full
2007	29 th August	20 mill. m ³	~ half-full
2009	6 th – 7 th September	20 mill. m ³	~ half-full
2010	8 th – 17 th September	11 mill. m ³	Less than half-full
2011	22 nd September	12 mill. m ³	Less than half-full
2014	11 th August	~35 mill. m ³	Less than full

A new jøkulhlaup occurred one year later in September 2011, and again the lake was less than half-full. The water level in Vatn 1051 was about 12-13 m higher in September 2013 than it was just before the event in 2011. The glacier surface adjacent to the lake was 1.4 m lower compared with measurements from October 2011. Thus, ice pressure decreased and water pressure increased. The most recent event began on 11th August 2014 and for the first time since 2005 the glacier-dammed lake was more than half-full before the initiation of the jøkulhlaup. This is also the earliest in the year that a jøkulhlaup has occurred, all the other events beginning either at the end of August or in September, but is probably related to July 2014 being several degrees warmer than average and fairly substantial rainfall in the area the preceding week (5th to 7th August). The exact volume of the most recent event was not precisely at the time of publication of this report, but was approximately 35 million cubic metres, calculated from the increase in lake level of Sisovatnet, downstream from Rundvassbreen. The pattern of events shows that the mechanism of the initiation of a flood event is complex and that Blåmannsisen is still able to surprise us.

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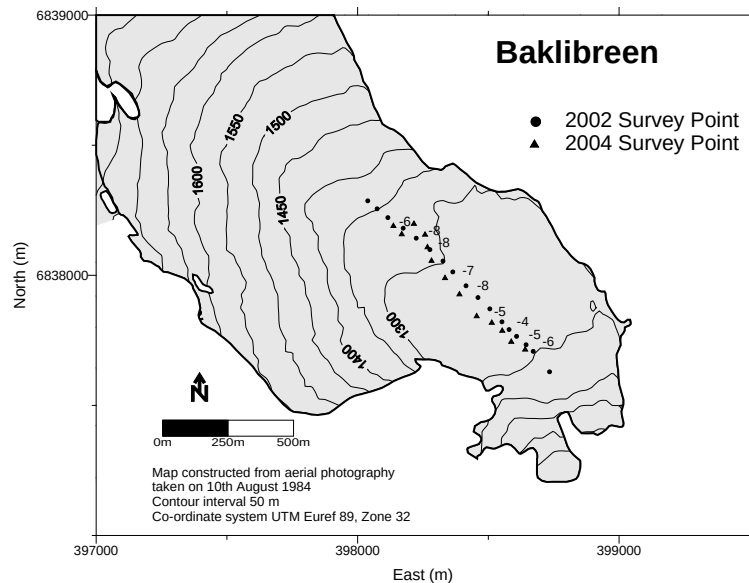
4.3 Baklibreen ice avalanche

A large ice avalanche occurred on 22nd July 1986 from Baklibreen (61°40'N, 7°05'E), a small outlet glacier of Jostedalsbreen, the largest ice mass in mainland Europe. The ice avalanche occurred in Krundalen, a side valley of Jostedal, and fell a total of 600 – 700 m killing three tourists walking along the footpath below. Baklibreen has an area of 3 km² and covers an elevation range from 1950 m a.s.l. to just over 1000 m a.s.l. The ice that fell is thought to have covered an area of 4000 m² and to have had a total volume of 200 000 m³.



Baklibreen in summer 1986 and on 12th October 2006. Photos: Bjørn Wold and Miriam Jackson.

To increase understanding of the Baklibreen event in particular and icefalls generally, measurements were initiated on the glacier in autumn 1987. Four stakes were set out in a longitudinal profile in the glacier's lower reaches. The stakes were used to measure horizontal and vertical velocity as well as ablation on the glacier between 1987 and 1990. Stake measurements showed that the lowest part of Baklibreen increased in thickness over this period. The biggest increase is at a distance of 200 to 300 m from the glacier front where the thickness increased about 5 m over 3 years.



Neighbouring glacier Bergsetbreen also advanced over this period and subsequently covered the footpath where the tourists were killed. Thus, as both glaciers continued to grow throughout the 1990s, although the danger of ice avalanche from Baklibreen was increased, as Bergsetbreen advanced over the footpath in the valley there was less danger of visitors

being present if an icefall occurred. From about 2000, both glaciers started to shrink and Bergsetbreen retreated substantially up the valley.

Throughout the 1990s and until 2004, the monitoring programme was changed to measurements of the height of the glacier surface measured by total station from a surveying point to prisms held by someone sitting in a helicopter on the glacier surface (height of the glacier surface was corrected for height of the prisms over the surface), at several different points along a longitudinal profile. The height of the glacier, and hence the thickness of the glacier, showed a steady decrease, as seen in figure showing survey points in 2002 and 2004 and surface lowering in this period. The monitoring programme was then terminated.

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Appendix A – Event overview: alphabetically by glacier name

J – jøkulhlaup/GLOF; PJ – potential jøkulhlaup; IA – ice avalanche; GLC – glacier length change; MA – mountaineering accident.

Glacier name	Date	Type	Damage
Austerdalsisen	22.07.1986	MA	1 dead, 1 injured
	1941–1954	J	Flood damage
	18.07.2007	IA	1 dead, 1 injured
	06.07.2014	MA	1 injured
Austre Okstindbreen	02.08.2011	MA	1 injured (minor injuries)
	11.08.2006	MA	1 injured (minor injuries)
	1976–1987	J	Flood
Baklibreen	27.07.1986	IA	3 dead
Bergsetbreen	1684	GLC	Farmland destroyed
	1743	GLC	High pastures destroyed
Blomstølskardbreen	–	PJ	
Blåisen	17.09.2002	MA	1 dead
Brenndalsbreen	12.12.1743	GLC, IA	Several dead, farm destroyed
	1743	J	Farmland flooded and destroyed
	1720	J	Farmland destroyed
Briksdalsbreen	20.08.2001	MA	1 injured
	28.10.2000	MA	1 injured
	06.05.2000	MA	1 injured
Buerbreen	08.08.1957	MA	1 dead, 2 injured
	1832–1878	GLC	Pastures destroyed
Bødalsbreen	28.07.1986	MA	1 dead, 4 injured
	1693	GLC	Farm damaged
Bøverbreen	19.07.2012	MA	1 injured (minor injuries)
	10.05.2008	MA	1 injured
	04.07.2006	MA	1 injured
	19.07.2003	MA	1 injured
	07.08.1998	MA	1 injured
	03.07.1998	MA	1 injured
	sep. 1986	MA	–
Dimdalsbreen	1968–1997	GLC	–
Engabreen	1723	GLC	Farm destroyed

Glacier name	Date	Type	Damage
Finnebrean	07.07.1977	MA	2 dead
Folgefonna, Nordre (NV)	Sep. 2009	J	None
	15.10.2000	MA	1 injured
Fonnalsbrean	1987	IA	None
	1723	GLC	Farm damaged
Fortundalsbrean (N)	–	PJ	
Frokosttindbrean	Regular (May-June 1987)	IA	–
Frostisen (V)	about 1900	GLC, IA	–
Glitterbrean	16.07.2001	MA	1 dead
Gråfjellsbrea	–	PJ	
Harbardsbrean (Ø and S)	04.08.2010	J	Flood
	27.06.2001	MA	1 dead
	1996–2001	J	Positive effects
Hengfjellet glacier (W)	–	PJ	
Illstigbrean	1934	J	Flood
	1932	J	Farms and a bridge destroyed, flood
Inste Årsnesdalsbrean	20.10.2001	MA	1 dead, 1 injured
Jostedalsbrean (V)	29.07.2000	MA	1 injured
Juvbrean	10.07.1957	MA	1 dead
Kjenndalsbrean	1667–1693	GLC	Farmlands destroyed, farm damaged
Koppangsbrean	2010–2014	J	Flood damage
Krokebrean	Early 20 th century	IA	–
	18 th century	GLC	Farms damaged
Leirbrean	16.08.1998	MA	1 injured
Lille Brekktind glacier	2-7.07.1934	MA	1 dead (never found)
Lodalsbrean	24.04.1969	MA	1 injured
Marabrean	Jul–Aug. 2004	J	–
Middagstuvebrean	26.08.1971	J	Extreme flood
Mjølkedalsbrean	1855–1937	J	Flood damage

Glacier name	Date	Type	Damage
Myklebustbreen (Ø)	1693	GLC, IA	Farms damaged
	1687	GLC, IA	Farm damaged
Nigardsbreen	10.08.2014	IA	2 dead
	02.06.2011	MA	1 injured
	16.08.2001	IA	None
	01.08.1998	MA	1 injured
	14.10.1995	MA	1 dead
	12.08.1994	GLC, IA	3 injured
	22.07.1986	GLC, IA	2 dead, 10 injured
	14.08.1979	Flood	32 mill NOK worth of flood damage
	Aug. 1743	GLC	Farm and farmland destroyed
	1742	GLC	Fields covered by ice
	Summer 1741	GLC	Farms damaged
	1710–1735	GLC	–
Pyttabrea	–	PJ	
Ramnefjellbreen (W)	Late 17 th - early 18 th century	GLC	Farms damaged
Reinvikisen	20.03.1966	IA	Farms damaged and destroyed
Rembesdalsskåka	04.08.2003	MA	1 injured
	13.08.2000	MA	1 injured
	30.06.2000	MA	1 injured
	06.08.1998	MA	1 injured
	1736–1938, 2014	J	Flood damage
Rundvassbreen	2001–2014	J	Positive effects
Sandelvbreen	21-22.03.1967	MA	4 dead
	Aug. 1945	MA	2 dead
Sauanutbreen	1938–1962	J	Flood damage
Sikilbreen	1838	MA	1 dead
Slingsbybreen	04.10.1986	MA	1 dead, 2 injured
Snøggeken	08.10.2005	MA	1 dead
Snøhetta (S)	18-22.10.2013	MA	1 dead
Steindalsbreen	01.07.2010	MA	None
Storjuvbreen	Jul. 2001	MA	2 injured
Strupbreen	1969	J	None
	1898	J	None

Glacier name	Date	Type	Damage
Styggebreen	27.07.2010	MA	1 injured
	07.08.2009	MA	1 dead
Styggebreen	13.09.2000	MA	1 injured
	Summer 1995	MA	–
	20.07.1993	MA	1 dead
Stølsnosbreen S	24.08.2001	MA	2 injured
Sundsreen	1697	IA, GLC	Farm destroyed
Supphellebreen/ Flatbreen	18 th century–2004	J	Flood damage, debris flow
Svartenutbreen	Aug. 2002	J	–
Svartisen V (V)	–	PJ	
Svartisheibreen	1989–2014	J	–
Svellnosbreen	24.08.2012	MA	1 injured
Tuftebreen	14.07.2001	MA	1 injured
	1741	GLC	Farm damaged
	1684	GLC	High pastures destroyed
Tunsbergdalsbreen	1896–1999	J	Flood damage
Tystigbreen (N, NW and SW)	16.08.2014, Aug. 2010	J	–
	Summer 1990	MA	1 injured
Vanndalsbreen	–	PJ	
Vestre Memurubreen	–	PJ	
Vetledalsbreen	about 1743	GLC	Farmland destroyed
Vetlefjordsbreen	1848	J	Farms devastated
	1820	J	Farms destroyed
	1741–1742	IA	–
	14.08.1741	J	Farmland damaged
Vetle Supphellebreen	14.07.2001	MA	1 injured
Vinnufonna	1850	GLC, IA	–

Appendix B – Event overview: chronologically

MA – mountaineering accident; J – jøkulhlaup/GLOF; IA – ice avalanche; GLC – glacier length change

Date	Type	Glacier name	Area name	Damage
1667–1693	GLC	Kjenndalsbreen	Jostedalsbreen	Farmlands destroyed, farm damaged
1684	GLC	Bergsetbreen	Jostedalsbreen	Farmland destroyed
	GLC	Tuftebreen	Jostedalsbreen	High pastures destroyed
1687	GLC, IA	Myklebustbreen (Ø)	Myklebustbreen	Farm damaged
1693	GLC	Bødalsbreen	Jostedalsbreen	Farm damaged
	GLC, IA	Myklebustbreen (Ø)	Myklebustbreen	Farms damaged
1697	GLC, IA	Sundsreen	Jostedalsbreen	Farm destroyed
Late 17 th - early 18 th century	GLC	Ramnefjellbreen (W)	Jostedalsbreen	Farms damaged
18 th century	J	Supphellebreen/ Flatbreen	Jostedalsbreen	Farm abandoned
	GLC	Krokebreen	Myklebustbreen	Damage to farms
1710-1735	GLC	Nigardsbreen	Jostedalsbreen	–
1720	J	Brenndalsbreen	Jostedalsbreen	Farmland destroyed
1723	GLC	Engabreen	Svartisen	Farm destroyed
	GLC	Fonndalsbreen	Svartisen	Farm damaged
1734	J	Brenndalsbreen	Jostedalsbreen	Farmland flooded and destroyed
1736	J	Rembesdalskåka	Hardangerjøkulen	Flood damage
1741	–	Tuftebreen	Jostedalsbreen	Farm damaged
	Summer	Nigardsbreen	Jostedalsbreen	Farms damaged
	14.08.	Vetlefjordsbreen	Jostefonni	Farmland damaged
1741-42	IA	Vetlefjordsbreen	Jostefonni	–
1742	GLC	Nigardsbreen	Jostedalsbreen	Fields covered by ice
1743	–	Vetledalsbreen	Jostedalsbreen	Farmland destroyed
	–	Bergsetbreen	Jostedalsbreen	High pastures destroyed
	August	Nigardsbreen	Jostedalsbreen	Farm and farmland destroyed
	12.12.	Brenndalsbreen	Jostedalsbreen	Several dead, farm destroyed
1813	J	Rembesdalskåka	Hardangerjøkulen	Flood damage

Date		Type	Glacier name	Area name	Damage
1820		J	Vetlefjordsbreen	Jostefonni	Farms destroyed
1832–1878		GLC	Buerbreen	Folgefonna	Pastures destroyed
1838		MA	Sikilbreen	Jostedalsbreen	1 dead
1842		J	Rembesdalskåka	Hardangerjøkulen	Flood damage
1848		J	Vetlefjordsbreen	Jostefonni	Farms devastated
1850		GLC, IA	Vinnufonna	Trollheimen	–
1855	11.08.	J	Mjølkedalsbreen	Jotunheimen	Flood
1861	17.09.	J	Rembesdalskåka	Hardangerjøkulen	2 bridges destroyed
1865		J	Mjølkedalsbreen	Jotunheimen	Flood damage
1875		J	Mjølkedalsbreen	Jotunheimen	Flood
1879		J	Mjølkedalsbreen	Jotunheimen	Flood
1893	August	J	Rembesdalskåka	Hardangerjøkulen	Flood, 35 mill m ³
1894		J	Mjølkedalsbreen	Jotunheimen	Flood
1896	July	J	Tunsbergdalsbreen	Jostedalsbreen	Flood damage
1897	July	J	Tunsbergdalsbreen	Jostedalsbreen	Flood damage
	17.08.	J	Rembesdalskåka	Hardangerjøkulen	Flood, 35 mill m ³
1898	–	J	Strupbreen	Lyngen	None
	July	J	Tunsbergdalsbreen	Jostedalsbreen	Flood damage
1899	July	J	Tunsbergdalsbreen	Jostedalsbreen	Flood damage
	02.08.	J	Mjølkedalsbreen	Jotunheimen	Flood
Early 20 th century		IA	Krokebreen	Myklebustbreen	–
1900	–	GLC, IA	Frostisen (V)	Skjomen	–
	August	J	Tunsbergdalsbreen	Jostedalsbreen	Flood, bridge swept away
1903	August	J	Tunsbergdalsbreen	Jostedalsbreen	Flood damage
1916	02.08.	J	Mjølkedalsbreen	Jotunheimen	Flood, 18 mill m ³
1921	03.08.	J	Mjølkedalsbreen	Jotunheimen	Flood, 33 mill m ³
1924		J	Supphellebreen/ Flatbreen	Jostedalsbreen	Flood damage, debris flow
1925	30.03.	J	Mjølkedalsbreen	Jotunheimen	Flood, 25 mill m ³
1926		J	Tunsbergdalsbreen	Jostedalsbreen	Flood, 25–30 mill m ³ , farms inundated
1927	18.08.	J	Mjølkedalsbreen	Jotunheimen	Flood, 17 mill m ³
1929	13.08.	J	Mjølkedalsbreen	Jotunheimen	Flood, 12 mill m ³
1931	14.11.	J	Mjølkedalsbreen	Jotunheimen	Flood, 19 mill m ³

	Date	Type	Glacier name	Area name	Damage
1932	–	J	Illstigbreen	Romsdalsfjella	Farms and a bridge destroyed, flood
	15.07.	J	Mjølkedalsbreen	Jotunheimen	Flood, 3 mill m ³
1934	–	J	Illstigbreen	Romsdalsfjella	Flood
	2-7.07.	MA	Lille Brekketind glacier	Sunnmøre	1 dead (never found)
1936	04.01.	J	Mjølkedalsbreen	Jotunheimen	Flood, 26 mill m ³
1937	30.01.	J	Mjølkedalsbreen	Jotunheimen	Flood, 3 mill m ³
	10.08.	J	Rembesdalskåka	Hardangerjøkulen	Flood, 11.5 mill m ³ , 165000NOK worth of flood damage
1938	30.07.	J	Sauanutbreen	Folgefonna	Large flood damage
	23.08.	J	Rembesdalskåka	Hardangerjøkulen	Flood
1941	July–August	J	Austerdalsisen	Svartisen	Flood, 30 mill m ³
1942	July–August	J	Austerdalsisen	Svartisen	Flood, 52 mill m ³
1944	July–August	J	Austerdalsisen	Svartisen	Flood, 38 mill m ³
	19.08.	J	Sauanutbreen	Folgefonna	Flood-protection structures damaged
1945	August	MA	Sandelvbrean	Jotunheimen	2 dead
	October	J	Austerdalsisen	Svartisen	Flood, 45 mill m ³
1946	July–August	J	Austerdalsisen	Svartisen	Flood, 56 mill m ³
1947	July–August	J	Austerdalsisen	Svartisen	Flood, 82 mill m ³
	November	J	Supphellebreen/ Flatbreen	Jostedalsbreen	Flood, debris flow; bridge, road and flood mitigation structures damaged
1948	July–August	J	Austerdalsisen	Svartisen	Flood, 92 mill m ³
	27.09.	J	Sauanutbreen	Folgefonna	Flood-protection structures damaged
1949	July–August	J	Austerdalsisen	Svartisen	Flood, 85 mill m ³
1950	July–August	J	Austerdalsisen	Svartisen	Flood, 120 mill m ³
1951	July–August	J	Austerdalsisen	Svartisen	Flood, 132 mill m ³
1952	July–August	J	Austerdalsisen	Svartisen	Flood, 113 mill m ³
1953	July–August	J	Austerdalsisen	Svartisen	Flood, 136 mill m ³
1954	July–August	J	Austerdalsisen	Svartisen	Flood, 150 mill m ³
1957	10.07.	MA	Juvbreen	Jotunheimen	1 dead
	08.08.	MA	Buerbreen	Folgefonna	1 dead, 2 injured
1962	18.10.	J	Sauanutbreen	Folgefonna	Farms destroyed and damaged
1966	20.03.	IA	Reinvikisen	Steigen	Farms damaged and destroyed
1967	21-22.03.	MA	Sandelvbrean	Jotunheimen	4 dead

Date		Type	Glacier name	Area name	Damage
1968–1997		GLC	Dimdalsbreen	Svartisen	–
1969	–	J	Strupbreen	Lyngen	None
	24.04.	MA	Lodalsbreen	Jostedalsbreen	1 injured
1970	21.06.	J	Tunsbergdalsbreen	Jostedalsbreen	Flood damage
1971	26.08.	J	Middagstuvebreen	Svartisen	Extreme flood
1973	11.08.	J	Tunsbergdalsbreen	Jostedalsbreen	Flood damage
1976	31.07.	J	Austre Okstindbreen	Okstindan	Flood, 0.34 mill m ³
1977	07.07.	MA	Finnebreen	Rauma	2 dead
	05.08.	J	Austre Okstindbreen	Okstindan	Flood
1978	August	J	Austre Okstindbreen	Okstindan	Flood
1979	30.06.	J	Austre Okstindbreen	Okstindan	Flood
	August	J	Austre Okstindbreen	Okstindan	Flood
	14.08.	Flood	Nigardsbreen	Jostedalsbreen	32 mill NOK worth of flood damage
1982	19.07.	J	Austre Okstindbreen	Okstindan	Flood
1984	29.07.	J	Austre Okstindbreen	Okstindan	Flood, 0.36 mill m ³
1985	July	J	Austre Okstindbreen	Okstindan	Flood
1986	July	J	Austre Okstindbreen	Okstindan	Flood
	22.07.	MA	Austerdalsisen	Svartisen	1 dead, 1 injured
		GLC, IA	Nigardsbreen	Jostedalsbreen	2 dead, 10 injured
	27.07.	IA	Baklibreen	Jostedalsbreen	3 dead
	28.07.	MA	Bødalsbreen	Jostedalsbreen	1 dead, 4 injured
	September	MA	Bøverbreen	Jotunheimen	–
	04.10.	MA	Slingsbybreen	Hurrungane	1 dead, 2 injured
1987	–	IA	Fonndalsbreen	Svartisen	None
	16.07.	J	Austre Okstindbreen	Okstindan	Flood
1989		J	Svartisheibreen	Svartisen	–
1990	Summer	MA	Tystigbreen (N, NW and SW)	Stryn	1 injured
1991	07.04.	J	Svartisheibreen	Svartisen	–
1993	20.07.	MA	Styggebreen	Jotunheimen	1 dead
1994	12.08.	GLC, IA	Nigardsbreen	Jostedalsbreen	3 injured

Date		Type	Glacier name	Area name	Damage
1995	Summer	MA	Styggebreen	Jotunheimen	–
	14.10.	MA	Nigardsbreen	Jostedalsbreen	1 dead
1996	October	J	Harbardsbreen (S)	Breheimen	Positive effects
1997	October	J	Harbardsbreen (S)	Breheimen	Positive effects
1998	03.07.	MA	Bøverbreen	Jotunheimen	1 injured
	01.08.	MA	Nigardsbreen	Jostedalsbreen	1 injured
	06.08.	MA	Rembesdalskåka	Hardangerjøkulen	1 injured
	07.08.	MA	Bøverbreen	Jotunheimen	1 injured
	16.08.	MA	Leirbreen	Jotunheimen	1 injured
	October	J	Harbardsbreen (S)	Breheimen	Positive effects
1999		J	Svartisheibreen	Svartisen	–
		J	Tunsbergdalsbreen	Jostedalsbreen	Flood damage
2000	06.05.	MA	Briksdalsbreen	Jostedalsbreen	1 injured
	30.06.	MA	Rembesdalskåka	Hardangerjøkulen	1 injured
	29.07.	MA	Jostedalsbreen (V)	Jostedalsbreen	1 injured
	13.08.	MA	Rembesdalskåka	Hardangerjøkulen	1 injured
	13.09.	MA	Styggebreen	Jotunheimen	1 injured
	October	J	Harbardsbreen (S)	Breheimen	Positive effects
	15.10.	MA	Folgefonna, Nordre (NV)	Folgefonna	1 injured
	28.10.	MA	Briksdalsbreen	Jostedalsbreen	1 injured
2001	27.06.	MA	Harbardsbreen (S)	Breheimen	1 dead
	July	MA	Storjuvbreen	Jotunheimen	2 injured
	14.07.	MA	Tuftebreen	Jostedalsbreen	1 injured
		MA	Vetle Supphellebreen	Jostedalsbreen	1 injured
	16.07.	MA	Glitterbreen	Jotunheimen	1 dead
	16.08.	IA	Nigardsbreen	Jostedalsbreen	None
	20.08.	MA	Briksdalsbreen	Jostedalsbreen	1 injured
	24.08.	MA	Stølsnosbreen S	Årdal	2 injured
	05.09.	J	Rundvassbreen	Blåmannsisen	Flood, 40 mill m ³ , positive effects
	October	J	Harbardsbreen (Ø)	Breheimen	Positive effects
	20.10.	MA	Inste Årsnesdalsbreen	Sunnmøre	1 dead, 1 injured
2002	August	J	Svartenutbreen	Folgefonna	–
	17.09.	MA	Blåisen	Hardangerjøkulen	1 dead
2003	19.07.	MA	Bøverbreen	Jotunheimen	1 injured
	04.08.	MA	Rembesdalskåka	Hardangerjøkulen	1 injured

	Date	Type	Glacier name	Area name	Damage
2004	08.05.	J	Supphellebreen/ Flatbreen	Jostedalsbreen	Flood damage, debris flow, farmland destroyed
	July–August	J	Marabreen	Jostedalsbreen	–
2005	29.08.	J	Rundvassbreen	Blåmannsisen	Flood, 35 mill m ³ , positive effects
	08.10.	MA	Snøggeken	Årdal	1 dead
2006	04.07.	MA	Bøverbreen	Jotunheimen	1 injured
	11.08.	MA	Austre Okstindbreen	Okstindan	1 injured
2007	18.07.	IA	Austerdalsisen	Svartisen	1 dead, 1 injured
	29.08.	J	Rundvassbreen	Blåmannsisen	Flood, 20 mill m ³ , positive effects
2008	10.05.	MA	Bøverbreen	Jotunheimen	1 injured
2009	07.08.	MA	Styggebreen	Jotunheimen	1 dead
	06.09.	J	Rundvassbreen	Blåmannsisen	Flood, 20 mill m ³ , positive effects
	12.09.	J	Folgefonna, Nordre (NV)	Folgefonna	Flood, 12000 m ³
2010	01.07.	MA	Steindalsbreen	Lyngen	None
	27.07.	MA	Styggebreen	Jotunheimen	1 injured
	August	J	Tystigbreen (N, NW and SW)	Stryn	–
	04.08.	J	Harbardsbreen (Ø)	Breheimen	Flood
	06.09.	J	Koppangsbreen	Lyngen	Flood damage
	08.09.	J	Rundvassbreen	Blåmannsisen	Positive effects
2011	–	J	Koppangsbreen	Lyngen	–
	02.06.	MA	Nigardsbreen	Jostedalsbreen	1 injured
	02.08.	MA	Austre Okstindbreen	Okstindan	1 injured
	22.09.	J	Rundvassbreen	Blåmannsisen	Flood, 12 mill m ³ , positive effects
2012	Summer	J	Koppangsbreen	Lyngen	–
	19.07.	MA	Bøverbreen	Jotunheimen	Minor injuries
	24.08.	MA	Svellnosbreen	Jotunheimen	1 injured
	Sept–Oct	J	Koppangsbreen	Lyngen	–
2013	04.06.	J	Koppangsbreen	Lyngen	Flood damage
	09.06.	J	Koppangsbreen	Lyngen	–
	19.06.	J	Koppangsbreen	Lyngen	–
	23.06.	J	Koppangsbreen	Lyngen	–
	26.06.	J	Koppangsbreen	Lyngen	–
	30.06.	J	Koppangsbreen	Lyngen	–

	Date	Type	Glacier name	Area name	Damage
2013	03.07.	J	Koppangsbreen	Lyngen	–
	12.08.	J	Koppangsbreen	Lyngen	–
	03.09.	J	Koppangsbreen	Lyngen	–
	18-22.10.	MA	Snøhetta (S)		1 dead
2014	17.06.	J	Koppangsbreen	Lyngen	–
	06.07.	MA	Austerdalsisen	Svartisen	1 injured
	10.08.	IA	Nigardsbreen	Jostedalsbreen	2 dead
	11.08.	J	Rundvassbreen	Blåmannsisen	Flood, 35 mill m ³ , positive effects
	16.08.	J	Tystigbreen (N, NW and SW)	Stryn	–
	25.08.	J	Rembesdalskåka	Hardangerjøkulen	Flood, 2 mill m ³
	Summer	J	Svartisheibreen	Svartisen	–

Appendix C – Event overview: by event type

Event type	Glacier name	Period / year	Number of registered events	Main glacier name
Potential jøkulhlaup (PJ)	Blomstølskardbreen	–	0	Søndre Folgefonna
	Fortundalsbreen (N)	–	0	Fortundalsbreen
	Gråfjellsbrea	–	0	Søndre Folgefonna
	Hengfjellet glacier (W)	–	0	–
	Pyttabrea	–	0	Søndre Folgefonna
	Svartisen V (V)	–	0	Vestre Svartisen
	Vanndalsbreen	–	0	–
	Vestre Memurubreen	–	0	Hellstugu/ Vestre Memurubreen
Active jøkulhlaup (J, PJ)	Folgefonna, Nordre (NV)	2009	1	Nordre Folgefonna
	Harbardsbreen (Ø)	1996–2010	6	Harbardsbreen
	Koppangsbreen	2010–2014	14	Strupbreen/ Koppangsbreen
	Marabreen	2004	1	Jostedalsbreen
	Middagstuvebreen	1971	1	Vestre Svartisen
	Rundvassbreen	2001–2014	7	Blåmannsisen
	Rembesdalskåka	1736–1938, 2014	9	Hardangerjøkulen
	Strupbreen	1898, 1969	2	Strupbreen/ Koppangsbreen
	Supphellebreen/ Flatbreen	18 th century–2004	4	Jostedalsbreen
	Svartenutbreen	2002	1	Søndre Folgefonna
	Svartisheibreen	1989–2014	4	Vestre Svartisen
	Tystigbreen (N, NW and SW)	2010, 2014	2*	Tystigbreen
Historical jøkulhlaup (J)	Austerdalsisen	1941–1954	11	Østre Svartisen
	Austre Okstindbreen	1976–1987	10	Okstindbreen
	Brenndalsbreen	1720, 1743	2	Jostedalsbreen
	Illstigbreen	1932, 1934	2	Illstigbreen
	Mjølkedalsbreen	1855–1937	15	Skogadalsbreen/ Mjølkedalsbreen/ Uranosbreen
	Sauanutbreen	1938–1962	4	Søndre Folgefonna
	Tunsbergdalsbreen	1896–1999	10	Jostedalsbreen
	Vetlefjordbreen	1741, 1820, 1848	3	Jostefonni

Event type	Glacier name	Period / year	Number of registered events	Main glacier name
Flood	Nigardsbreen	1979	1	Jostedalsbreen
Glacier length change (GLC)	Bergsetbreen	1684, 1743	2	Jostedalsbreen
	Buerbreen	1832–1878	1	Søndre Folgefonna
	Bødalsbreen	1693	1	Jostedalsbreen
	Dimdalsbreen	1968–1997	1	Vestre Svartisen
	Engabreen	1723	1	Vestre Svartisen
	Fonndalsbreen	1723	1	Vestre Svartisen
	Kjenndalsbreen	1667–1693	1	Jostedalsbreen
	Nigardsbreen	1710–1743	4	Jostedalsbreen
	Krokebreen	18 th century	1	–
	Ramnefjellbreen (W)	Late 17 th – early 18 th century	1	Ramnefjellbreen
	Tuftebreen	1684, 1741	2	Jostedalsbreen
	Vetledalsbreen	about 1743	1	Jostedalsbreen
GLC, IA	Brenndalsbreen	1743	1	Jostedalsbreen
	Frostisen (V)	about 1900	1	Frostisen
	Myklebustbreen (Ø)	1687, 1693	2	Myklebustbreen
	Nigardsbreen	1986, 1994	2	Jostedalsbreen
	Sundsreen	1697	1	Jostedalsbreen
	Vinnufonna	1850	1	–
Ice avalanche (IA)	Austerdalsisen	2007	1	Østre Svartisen
	Baklibreen	1986	1	Jostedalsbreen
	Krokebreen	Early 20 th century	1	–
	Fonndalsbreen	1987	1	Vestre Svartisen
	Frokosttindbreen	Regular	unknown	Vestre Svartisen
	Nigardsbreen	2001, 2014	2	Jostedalsbreen
	Reinvikisen	1966	1	–
	Vetlefjordbreen	1741-42	1	Jostefonni
Mountaineering accidents (MA)	Austerdalsisen	1986, 2014	2	Østre Svartisen
	Austre Okstindbreen	2006, 2011	2	Okstindbreen
	Blåisen	2002	1	Hardangerjøkulen
	Briksdalsbreen	2000-2001	3	Jostedalsbreen
	Buerbreen	1957	1	Søndre Folgefonna

Event type	Glacier name	Period / year	Number of registered events	Main glacier name
Mountaineering accidents (MA)	Bødalsbreen	1986	1	Jostedalsbreen
	Bøverbreen	1986–2012	7	Smørstabbreen
	Finnebreen	1977	1	–
	Folgefonni, Nordre (NV)	2000	1	Nordre Folgefonna
	Glitterbreen	2001	1	Gråsubreen/ Grotbreen/ Glitterbreen
	Harbardsbreen (S)	2001	1	Harbardsbreen
	Inste Årsnesdalsbreen	2001	1	–
	Jostedalsbreen (V)	2000	1	Jostedalsbreen
	Juvbreen	1957	1	–
	Leirbreen	1998	1	Smørstabbreen
	Lille Brekktind glacier	1934	1	–
	Lodalsbreen	1969	1	Jostedalsbreen
	Nigardsbreen	1995–2011	3	Jostedalsbreen
	Rembesdalsskåka	1998–2003	4	Hardangerjøkulen
	Sandelvbrean	1945,1967	2	Smørstabbreen
	Sikilbreen	1838	1	Jostedalsbreen
	Slingsbybreen	1986	1	–
	Snøggeken	2005	1	–
	Snøhetta (S)	2013	1	–
	Steindalsbreen	2010	1	–
	Storjuvbreen	2001	1	–
	Styggebreen	1995–2014	5	–
	Stølsnosbreen S	2001	1	Stølsnosbreen
	Svellnosbreen	2012	1	–
	Tuftebreen	2001	1	Jostedalsbreen
	Vetle Supphellebreen	2001	1	Jostedalsbreen
	Tystigbreen (N, NW and SW)	1990	1	Tystigbreen

* – there were several jøkulhlaups from different glacier-dammed lakes in 2010.

Appendix D – Glacier overview and coding: alphabetically by glacier name

Glacier name	Alternative names	Main glacier name	Municipality	County	WGI ID	NEZ Atlas ID	NEZ database ID	GLIMS ID
Austerdalsisen	Østerdalsisen	Østre Svartisen	Rana	Nordland	N4A000CX033	1361	1102	G345864E66566N
Austre Okstindbreen	Okstindbreen austre	Okstindbreen	Hemnes	Nordland	N4A000CW002	1438	1066	G345704E66006N
Baklibreen		Jostedalbreen	Luster	Sogn & Fjordane	N4A000A4013	2309	411	G352941E61672N
Bergsetbreen	Krondalsbreen	Jostedalbreen	Luster	Sogn & Fjordane	N4A000A4013	2318	410	G352964E61656N
Blomstølskardsbreen	Blomsterskardbreen	Søndre Folgefonna	Elne	Hordaland	N4A000AJ009	3141	234	G353638E59989N
Blåisen		Hardangerjøkulen	Ulvik	Hordaland	N4A000AG001	2966	199	G352525E60546N
Brenndalsbreen	Åbrekkebreen	Jostedalbreen	Stryn	Sogn & Fjordane	N4A000BS009/ N4A000A4018	2305/ 2301	613	G353036E61687N
Briksdalsbreen	Brigsdalsbreen	Jostedalbreen	Stryn	Sogn & Fjordane	N4A000BS010	2316	612	G353083E61656N
Buerbreen	Buarbreen, Øvre Buerbreen, Nedre Buerbreen	Søndre Folgefonna	Odda	Hordaland	N4A000AK005	3131	262	G353606E60041N
Bødalsbreen		Jostedalbreen	Stryn	Sogn & Fjordane	N4A000BT019	2273	636	G352856E61762N
Bøverbreen	Bøverbreen	Smørstabbreen	Lom	Oppland	N4A000AD048	2643	122	G351905E61549N
Dimdalsbreen	Dimdalsbreen (Ø)	Vestre Svartisen	Meløy	Nordland	N4A000C4006	1090	1215	G346119E66697N
Engabreen	Engenbreen	Vestre Svartisen	Meløy	Nordland	N4A000C4011	1094	1220	G346147E66657N

Glacier name	Alternative names	Main glacier name	Municipality	County	WGI ID	NEZ Atlas ID	NEZ database ID	GLIMS ID
Finnebreen		–	Rauma	Møre & Romsdal	N4A000CG032	1765	874	G352378E62450N
Folgefonni, Nordre (NV)		Nordre Folgefonna	Jondal	Hordaland	N4A000AJ013	3113	251	G353534E60218N
Fomdalsbreen		Vestre Svartisen	Rødøy/ Meløy	Nordland	N4A000C4012	1097	1221	G346239E66650N
Fortundalsbreen (N)		Fortundalsbreen	Luster/Skjåk	Sogn & Fjordane	N4A000AE018	2505	150	G352292E61736N
Frokostindbreen	Frukosttinsbreen	Vestre Svartisen	Meløy	Nordland	N4A000C4005	1089	1214	G346062E66701N
Frosisen (V)		Frosisen	Ballangen	Nordland	N4A000DT008	743	1497	G342876E68251N
Glitterbreen	Glitterbreen	Gråsubreen/ Grobbreen/ Glitterbreen	Lom	Oppland	N4A000AD003	2745	66	G351420E61648N
Gråfjellsbrea	Gråbreen	Søndre Folgefonna	Kvinherad	Hordaland	N4A000AK007	3127	243	G353592E60078N
Harbardsbreen (Ø and S)		Harbardsbreen	Luster	Sogn & Fjordane	N4A000A2004/ N4A000A2003	2514/ 2516	358/ 394	G352332E61681N/ G352341E61670N
Hengfjellet glacier (W)		–	Beiarn/Rana	Nordland	N4A000DE003	1260	1281	G345331E66748N
Illstigbreen		Illstigbreen	Norddal	Møre & Romsdal	N4A000B8004	1824	834	G352391E62245N
Inste Årnesdalsbreen		–	Ørsta	Møre & Romsdal	N4A000BW023	1971	753	G353649E62313N
Jostedalsbreen (V)		Jostedalsbreen	Luster	Sogn & Fjordane	N4A000BQ017	2332	508	G353173E61583N

Glacier name	Alternative names	Main glacier name	Municipality	County	WGI ID	NVE-Atlas ID	NVE-database ID	GLIMS ID
Juvbreen	Veslgjuvbreen [Vestlgjuvbreen, Veslejuvbreen]	–	Lom	Oppland	N4A000AD025	2601	97	G351650E61664N
	Kjelen [Kjelbreen]	–	Lom	Oppland	N4A000AD026	2598	98	G351653E61671N
Kjemdalsbreen		Jostedal sbreen	Stryn	Sogn & Fjordane	N4A000BT023	2296	634	G352975E61711N
Koppangsbreen		Strupbreen/ Koppangsbreen	Lyngen	Troms	N4A000EH087	205	1983	G339856E69688N
Krøkebreen		–	Stryn	Sogn & Fjordane	N4A000BS018	2251	603	G353240E61768N
Leirbreen	Leirbreen	Smørstabbreen	Lom	Oppland	N4A000AD047	2638	121	G351891E61562N
Lille Brekkeind glacier		–	Sykkylven	Møre & Romsdal	N4A000BY009	1993	756	G353295E6226N
Lodalsbreen	Småttene, Hanken, Strupebreen	Jostedal sbreen	Luster	Sogn & Fjordane	N4A000A4019	2266	418	G352811E61777N
Marabreen		Jostedal sbreen	Jølster	Sogn & Fjordane	–	2364	531	G353288E61508N
Middagstuvebreen	Svartisen V (V)	Vestre Svartisen	Meløy	Nordland	N4A000C4001	1080	1210	G345993E66746N
Mjølkedal sbreen		Skogadal sbreen/ Mjølkedal sbreen/ Uranosbreen	Vang	Oppland	N4A000AA001	2717	1	G351815E61433N
Myklebustbreen (Ø)		Myklebustbreen	Stryn	Sogn & Fjordane	N4A000BS016	2286	605	G353267E61714N
Nigardsbreen		Jostedal sbreen	Luster	Sogn & Fjordane	N4A000A4014	2297	413	G352901E61715N

Glacier name	Alternative names	Main glacier name	Municipality	County	WGI ID	NE-Atlas ID	NE-database ID	GLIMS ID
Pyttabrea	Pyttabreen, Folgeforni Søndre (N)	Søndre Folgefonna	Kvinnherad	Hordaland	N4A000AJ007	3132	240	G353716E60028N
Rammefjellbreen (W)		Rammefjellbreen	Stryn	Sogn & Fjordane	N4A000BS002	2239	621	G353110E61800N
Reinvikisen		–	Sørfold	Nordland	N4A000DM002	865/ 868	1461	G344372E67714N/ G344358E67710N
Rembesdalskåka	Rembesdalskåki	Hardangerjøkulen	Eidfjord	Hordaland	N4A000AO001	2968	279	G352595E60537N
Rundvassbreen	Blåmannsisen (N)	Blåmannsisen	Fauske	Nordland	N4A000DI021	941	1417	G343957E67291N
Sandelvbrean	Sandelvbreen	Smørstabbrean	Lom	Oppland	N4A000A1018	2652	335	G351852E61537N
Sauanutbreen	Sauabreen	Søndre Folgefonna	Eina/Odda	Hordaland	N4A000AK008	3142	233	G353590E59983N
Sikilbreen	Sikilbreen V	Jostedalbreen	Luster	Sogn & Fjordane	N4A000AE032	2457	167	G352600E61867N
Slingsbybreen		–	Årdal/Luster	Sogn & Fjordane	N4A000A1009	2694	325	G352121E61459N
Snøggeken	Falkbreen	–	Årdal	Sogn & Fjordane	N4A000A1036	2729	350	G351891E61389N
Snøhetta (S)		–	Dovre	Oppland	N4A000CJ020	1738	938	G350744E62314N
Steindalsbreen	Steindal	–	Tromsø/Storfjord	Troms	N4A000EH053	288	1949	G340148E69395N
Storjuvbreen	Storjuvbreen, Storgjuvbreen	–	Lom	Oppland	N4A000AD027	2614	99	G351711E61636N
Struppbreen		Struppbreen/ Koppangsbreen	Lyngen	Troms	N4A000EH088	200	1984	G339872E69706N
Styggebrean	Styggebreen, Piggbrean	–	Lom	Oppland	N4A000AD024	2608	96	G351659E61645N

Glacier name	Alternative names	Main glacier name	Municipality	County	WGI ID	NVE-Atlas ID	NVE-database ID	GLIMS ID
Stølsnosbreen S		Stølsnosbreen	Årdal	Sogn & Fjordane	N4A000A1032	2727	349	G351917E61391N
Sundsdbreen		Jostedal sbreen	Stryn	Sogn & Fjordane	N4A000BS006	2281	617	G353110E61732N
Supphellebreen	Flatbreen, Store Supphellebreen	Jostedal sbreen	Sogndal	Sogn & Fjordane	N4A000A8015	2352	464	G353199E61531N
Svartenutbreen	Folgefonni Søndre (NØ)	Søndre Folgefonna	Odda	Hordaland	N4A000AJ015	3139	260	G353583E5998N
Svartisen V (V)		Vestre Svartisen	Meløy	Nordland	N4A000C4003	1083	1212	G346009E66725N
Svarishelbreen		Vestre Svartisen	Rødøy	Nordland	N4A000CX009	1135	1078	G346239E66557N
Svellnosbreen	Svellnosbreen	–	Lom	Oppland	N4A000AD023	2622	95	G351673E61625N
Tuftebreen	Tverbreen (up till 1900)	Jostedal sbreen	Luster	Sogn & Fjordane	N4A000A4013	2308	412	G352913E61677N
Tunsbergdalsbreen		Jostedal sbreen	Luster	Sogn & Fjordane	N4A000A4007	2320	403	G353002E61646N
Tystigbreen (N, NW and SW)	Tystigbreen (N)	Tystigbreen	Stryn	Sogn & Fjordane	N4A000BU019	2428	684	G352671E61929N
	Tystigbreen (NV)	Tystigbreen	Stryn	Sogn & Fjordane	N4A000BU018	2429	686	G352643E61931N
	Tystigbreen (SV)	Tystigbreen	Stryn	Sogn & Fjordane	N4A000BU022	2435	685	G352670E61915N
Vandalsbreen		–	Luster	Sogn & Fjordane	N4A000A4028	2531/2532	435	G352597E61592N/ G352587E61592N
Vestre Memnubreen	Vestre Memnubreen	Hellstugu/ Vestre Memnubreen	Lom	Oppland	N4A000AB031	2772	46	G351546E61542N

Glacier name	Alternative names	Main glacier name	Municipality	County	WGI ID	NVE-Atlas ID	NVE-database ID	GLIMS ID
Vetledalsbreen	Grønneskredbreen	Jostedalbreen	Luster	Sogn & Fjordane	–	2326	409	G352916E61628N
Vetlefjordbreen	Jostefonn (S), Vetlefjordsbreen	Jostefonni	Balestrand	Sogn & Fjordane	N4A000A8009	2148	442	G353458E61416N
Vette Supphellebreen	Jostedalbreen (S), Vesle Supphellebre, Vetlebreen, Veslebreen	Jostedalbreen	Luster/ Balestrand	Sogn & Fjordane	N4A000A5017	2355	465	G353163E61530N
Vinnufonna		–	Sunnadal	Møre & Romsdal	N4A000CN001	1601	982	G351341E62680N

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