



# Glacier products used in NVE



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*CryoLand, workshop, 8 October 2014, Oslo*

# Glaciers in Norway

## Motivation

- Glaciers have importance for hydropower and tourism
- Glaciers are sensitive climate indicators (*IPCC, 2007; 2013*)
- Glaciers can be dangerous: outburst floods & ice falls

## Facts

- Glacier cover 0.7% of land area,  $2692 \pm 81 \text{ km}^2$   
(*Andreassen & Winsvold, 2012, CryoClim*)
- Total of 2534 (3143) glaciers
- Glacier types: small ice patches & large ice caps



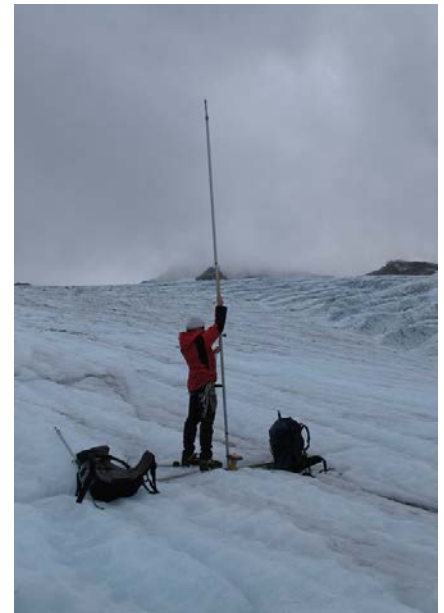
*Jostedalbreen & Spørteggbreen. Foto: Hallgeir Elvehøy*



*Crevasses on Nigardsbreen. Photo: Ole Magnus Tønberg*

# Glacier monitoring

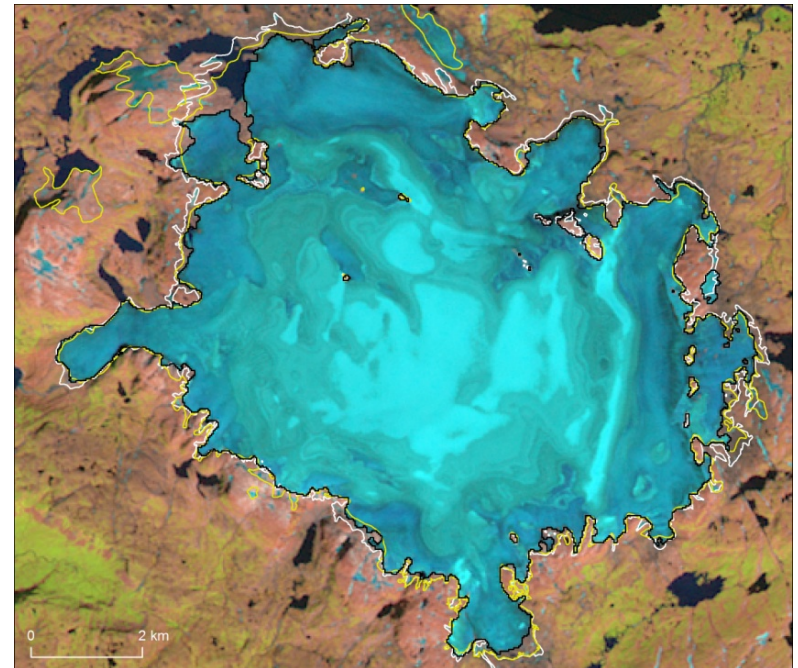
- Mass balance (since 1949)
- Length change (since 1899)
- Map surveys (air photo > lidar)
- Special investigations (ice velocity, thickness, GLOFs, hydrology, etc)
- Glacier inventories



Measuring mass balance. Photo: NVE



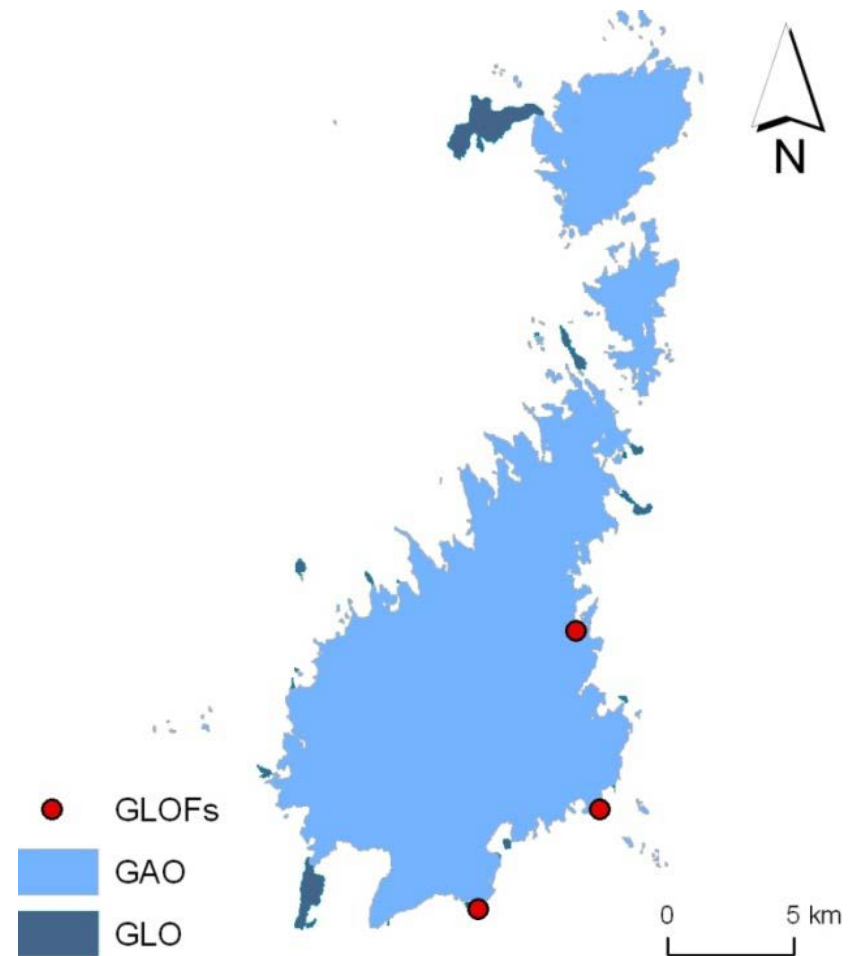
Blåmannsisen. Photo: Hans M. Hjemaas



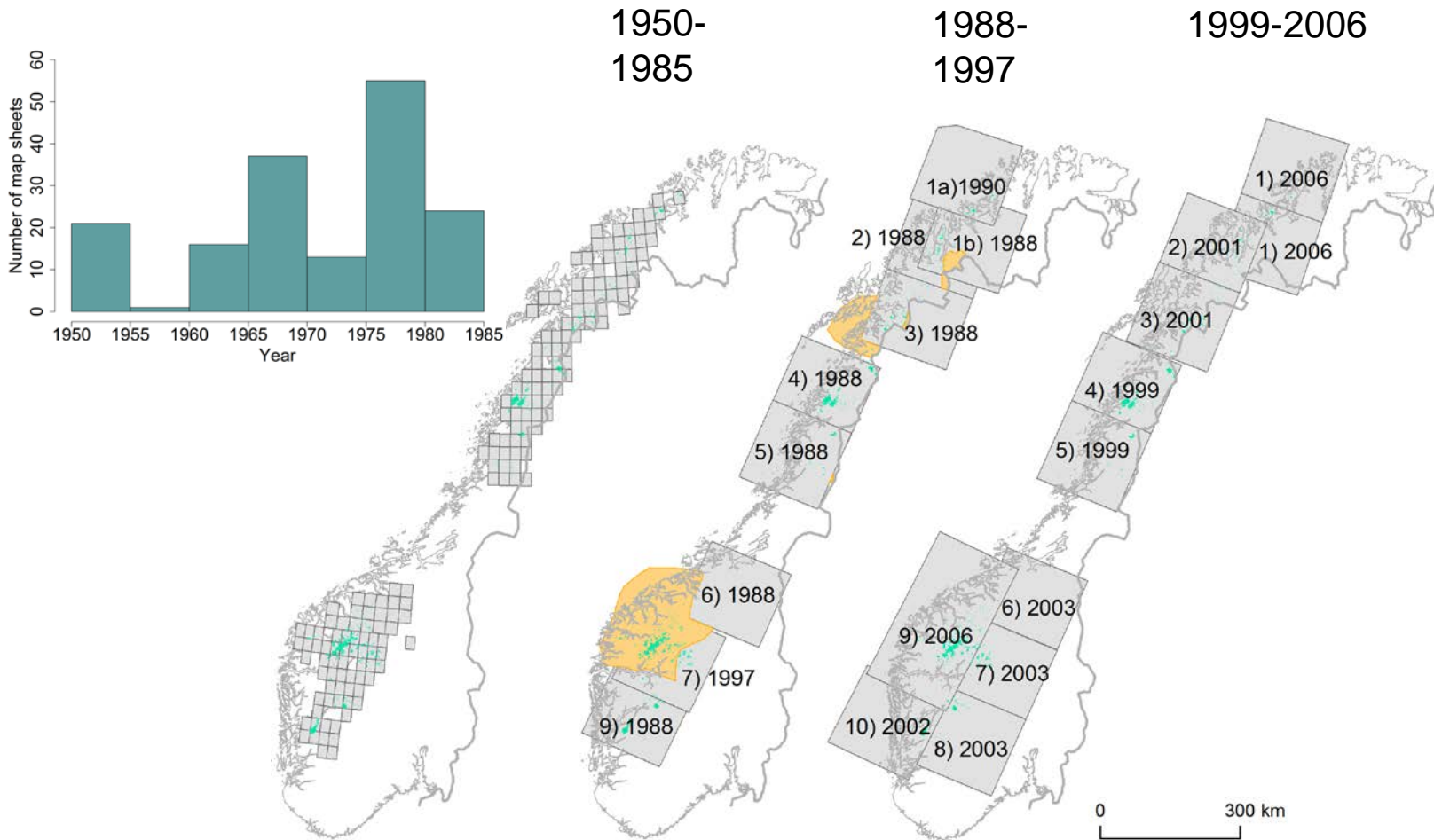
Area change Hardangerjøkulen

# CryoClim: Glacier products mainland Norway

- Glacier Area Outline - **GAO**  
(wms, shape, 3 (4) data sets)
- Glacier Lake Outline – **GLO**  
(wms, shape, 2 data sets)
- Glacier Lake Outburst Flood - **GLOF**  
(wms, points & [web application](#))
- Climate Indicator products – **CI**  
([web application](#))
  - Surface mass balance
  - Glacier length
  - Glacier area
- Glacier Periodic Photo – **GPP**  
([web application](#))

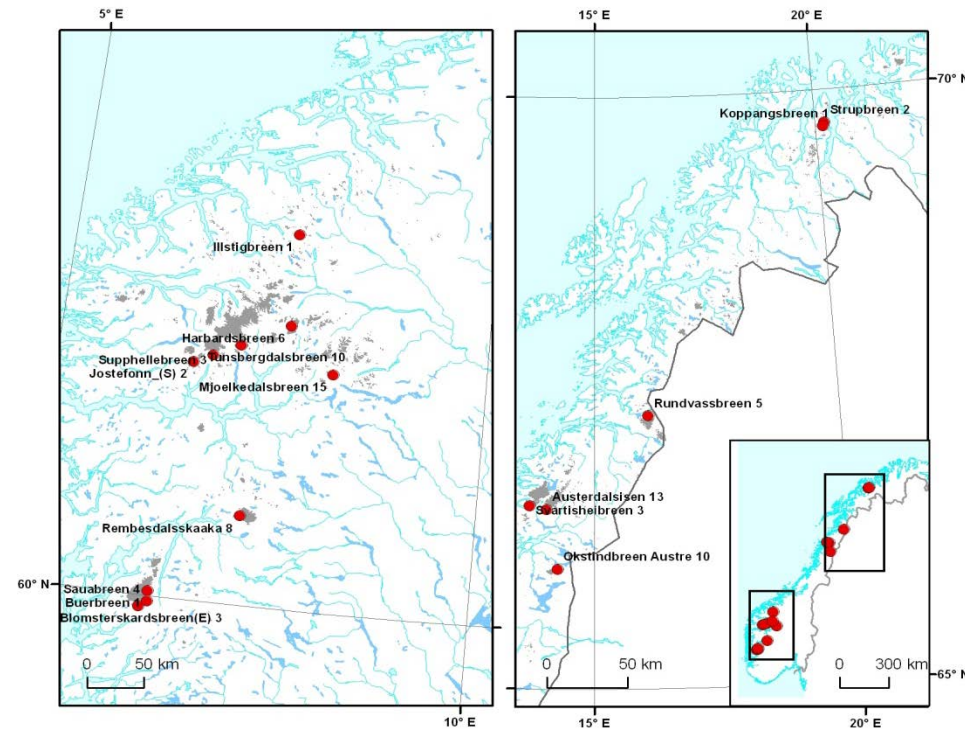
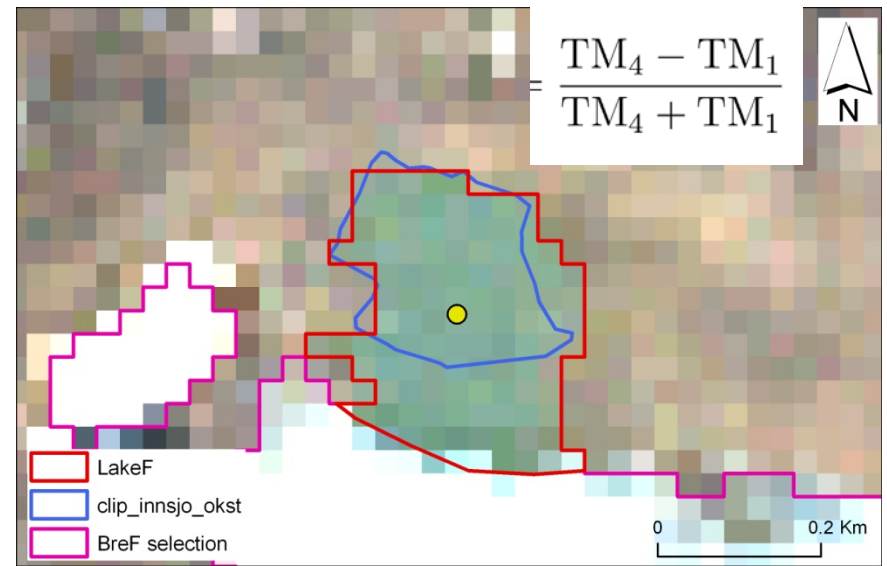


# GAO and GLO time series Norway



# Glacier lake outlines & GLOFs

- **Glacier lakes:** defined defined as water bodies that intersected or within 50 m of GAO.
- GLO 1999-2006 used NDWI (Normalized Difference Water Index)
- GLO 1988-1997 manual digitization (*Only locations where glacier lakes were detected in GLO 1999-2006*)
- Point layer of observed GLOFs



# CryoClim applications

- Climate indicators
- Glacier periodic photos
- Glacier lake outburst floods

<http://glacier.nve.no/viewer/CI/en/cc>

<http://glacier.nve.no/viewer/GPP/en/cc>

<http://glacier.nve.no/viewer/GLOF/en/cc>

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Glaciers are key indicators of climate change. Mountain glaciers are particularly good indicators of climate change because they respond more quickly than most other ice bodies on Earth (Lenke et al., 2007). While the mass balance of a glacier reflects annual weather directly, records of length change (also termed front-position change) can be used for climate change detection on a decadal-to-century time scale. When a glacier advances or retreats its surface area also changes. Remote sensing observations of glacier area are valuable to detect glacier changes for larger regions.

The climate change indicator products of glaciers in mainland Norway include:

- surface mass balance
- length change
- area

The products are available for a selection of individual glaciers with long time series. Glacier surface mass balance and glacier length change are retrieved directly from NVE's databases, whereas the area product is made from available remote sensing observations.

*Overview of individual glaciers with climate indicator products. Select a glacier to view the mass balance, length change and area data. Click the button to download data. ID refers to Glacier ID in the Glacier inventory of Norway (Andreasen et al., 2012). LIA refers to Little Ice Age maximum extent (which is ~18th century for these glaciers).*

ID	Name	Mass balance	Length change	Area
2327	Austerdalsbreen		1905-20, 1933-	1966-2006
2316	Briksdalsbreen		1900-	1966-2006
1004	Engabreen	1970-	1903-	LIA-2008
2289	Fåbergstølsbreen		1890-	1966-2006

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## Name - Glacier ID

- Åttotbreen - 2078
- Austerdalsbreen - 2478
- Austerdalsbreen - 2327
- Austre Okstindbreen - 1438
- Bergsetbreen - 2318
- Badalsbreen - 2273
- Rondhusbreen - 3133
- Bøyerbreen - 2643
- Boyabreen - 2349
- Brenndalsbreen - 2305
- Briksdalsbreen - 2316
- Buerbreen - 3131
- Engabreen - 1094
- Fåbergstølsbreen - 2289
- Fonndalsbreen - 1097
- Harbardsbreen - 2514
- Hellstugubreen - 2768
- Kjenndalsbreen - 2206
- Langfjordstølsbreen - 54
- Leirbreen - 2638
- Lodalsbreen - 2266
- Melkevollbreen - 2324
- Nigardsbreen - 2297
- Rembesdalskåka - 2068
- Stegobreen - 2480

**Glacier Periodic Photo**

The Glacier Periodic Photo (GPP) series show photos of selected glaciers in mainland Norway. The photo series illustrate how a selection of Norwegian glaciers has changed during the last 10-140 years. The earliest photos are from 1869. The majority of the pictures are from the last 20 years. The number of photos varies between the glaciers. Please note that the photos are not necessarily taken from the same location. The photo angle, view and line of sight will vary.

Click on the glaciers in the left menu and see the photos as a slide show. For each glacier it is also possible to see a comparison of two photos. The source of the data is NVE's photo archive, with contributions from NVE collaborators.

*Bergsetbreen (ID 2318) in 1996 and 2008. Bergsetbreen reacts quickly to changes in climate. The glacier advanced in the 1990s as a result of a transient mass surplus. Between 2000 and 2008 the glacier retreated. The lower tongue became completely separated from the glacier in 2006. Photos: Hallgeir Elvehey and Kristen Åsen.*

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## Name - Glacier ID

- Austerdalsisen - 1361
- Austre Okstindbreen - 1438
- Buerbreen - 3131
- Harbardsbreen - 2514
- Illstigbreen - 1824
- Jostefonni - 2145
- Koppangsbreen - 205
- Mjølkedalsbreen - 2717
- Rembesdalskåka - 2968
- Rundvassbreen - 941
- Sauanutbreen - 3142
- Strupbreen - 200
- Supphellebreen - 2352
- Svartisheibreen - 1135
- Tunsbergdalsbreen - 2320
- Vestre Svartisen - 1080

A jökulhlaup or Glacier Lake Outburst Flood (GLOF) is a sudden release of water from a glacier. The water source can be a glacier-dammed lake, a pro-glacial moraine-dammed lake or water stored within, under or on the glacier. The term *jökulhlaup* is Icelandic in origin (from the Icelandic *jökull* = glacier, *hlaup* = floodburst).

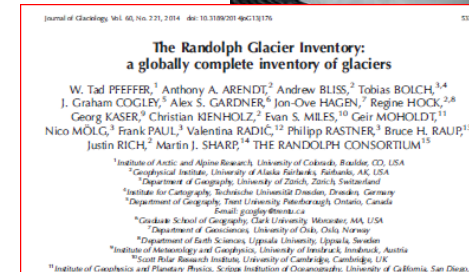
This GLOF application gives overview of registered GLOFs from glaciers in mainland Norway. Click on the glaciers in the left menu to see more information on the registered events.

*Rundvassbreen from Blåmannsisen calves into Øvre Messtingnalvann. Several jökulhlaups, or Glacier Lake Outburst Floods (GLOFs), have occurred from this glacier. Photo: Hans Martin Hjemaa, May 2012.*

# Usage of products



- Outlines delivered to GLIMS (global database of land ice) & RGI
- Area and length change studies from LIA to present (publications, book chapters, inventory book)
- Glacier masks used for modelling
  - ice volume estimate of Norway
- Other users:
  - Meteorological institute
  - Hydropower companies
  - Students
  - Researchers



The Cryosphere Discuss., 8, 3069–3115, 2014  
www.the-cryosphere-discuss.net/8/3069/2014/  
doi:10.5194/tcd-8-3069-2014  
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The Cryosphere  
Discussions  
Open Access

This discussion paper is/has been under review for the journal The Cryosphere (TC).  
Please refer to the corresponding final paper in TC if available.

## Glacier area and length changes in Norway from repeat inventories

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# Outlook

- Sentinel/Landsat 8
  - Better **temporal** and **spatial** resolution
- Glacier outlines: repeat surveys
  - > **Change assessment**
- Glacier lakes: focusing on GLOF sites
  - > **Monitor development of lakes**
- End-of-season snow line:
  - > **Mass balance estimates**  
(if annual imagery)
- Ice velocity & ice divides
- ++

