Icelandic Meteorological Office

Veðurstofa Íslands

A supersite for cryospheric studies in Iceland?

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Icelandic Meteorological Office

Collaborators:

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Earth Science Institute, University of Iceland

MODIS Satellite image of Iceland
almost entirely covered with snow

The cryosphere in Iceland

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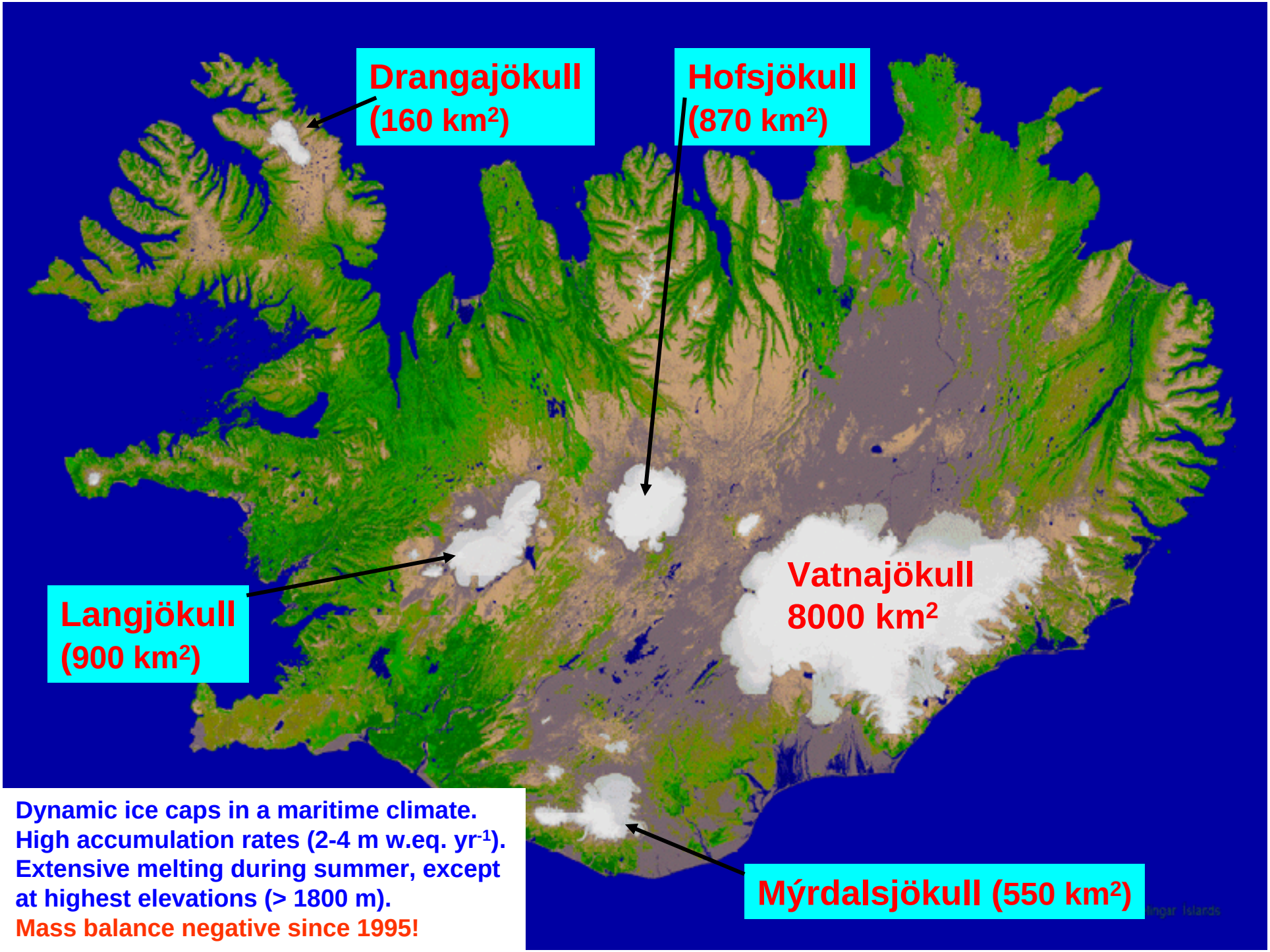
Located just below the Arctic Circle

~40% of the precipitation falls as snow

Sea ice frequently drifted to N-coast during past colder climates

Limited permafrost above 600 m elevation

Ice caps and glaciers cover 11% of the country



Dynamic ice caps in a maritime climate.
High accumulation rates (2-4 m w.eq. yr^{-1}).
Extensive melting during summer, except at highest elevations (> 1800 m).
Mass balance negative since 1995!

Ice caps/glaciers in Iceland

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- Total area: ~11,000 km^2
- Total volume: ~3600 km^3
- Equals: ~32 m thick water layer spread over the entire country
- Equals: ~18 years of precipitation falling on the entire country
- Sea-level equivalent: ~1 cm
- Age of oldest ice: ~ 1000 years
- All glaciers in Iceland are temperate (warm-based)
- High precipitation levels (2-4 m, water equivalent)
- Dynamic behaviour
- Respond rapidly to climatic variations

Proximity to inhabited areas

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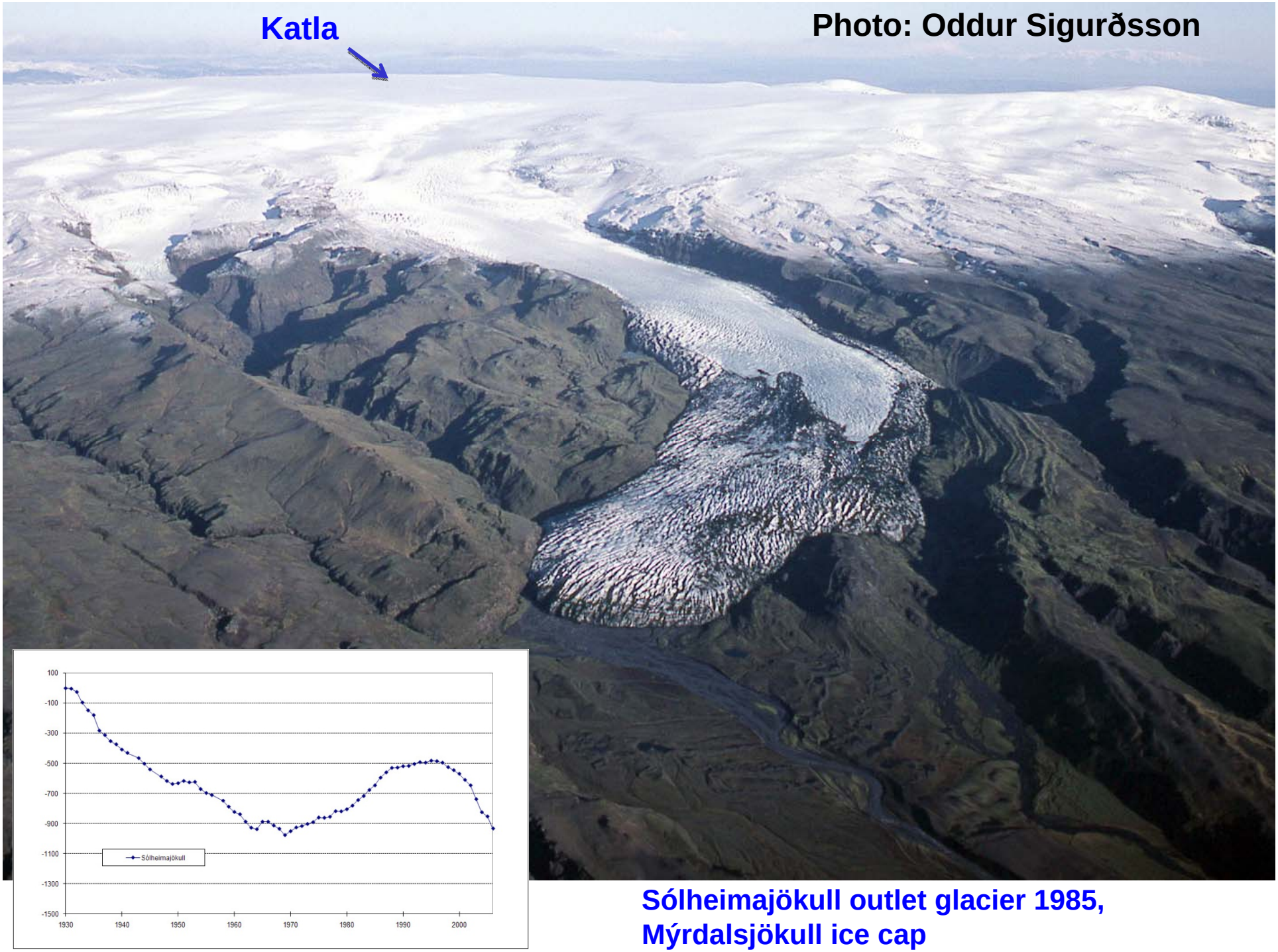
Records of glacier changes already in the sagas.

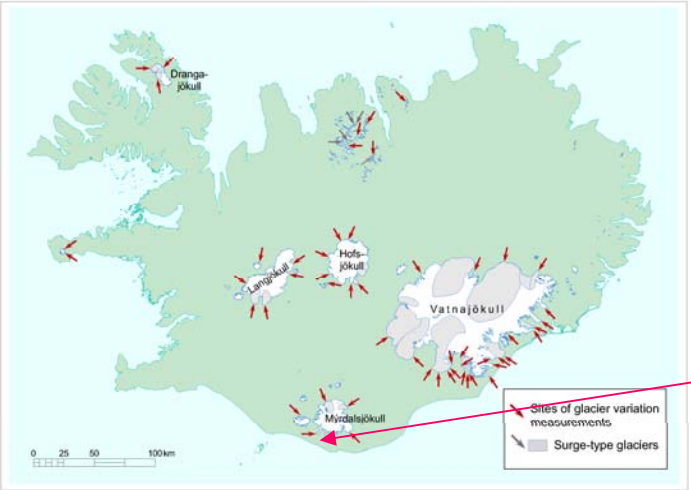
Human settlements strongly affected by glaciers, subglacial volcanism and jökulhlaups through the ages.

Monitoring of glacier terminus variations initiated in 1930, carried out by volunteers in the Icelandic Glaciological Society since 1950.

The large ice caps can be reached by a 2-6 hr drive from the capital region. Base camps for scientific expeditions exist.



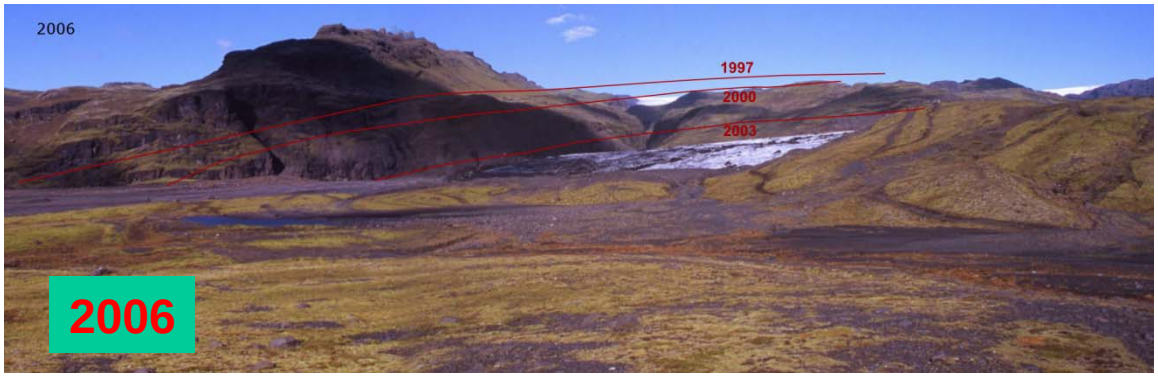
Sólheimajökull outlet glacier 1985, Mýrdalsjökull ice cap



Sólheimajökull glacier

Rapid retreat of ice margins (20-50 m annually) since 1995.

Each year, ~20 km^2 of new, previously ice-covered land is exposed in Iceland.



Temperature changes 1840-2006

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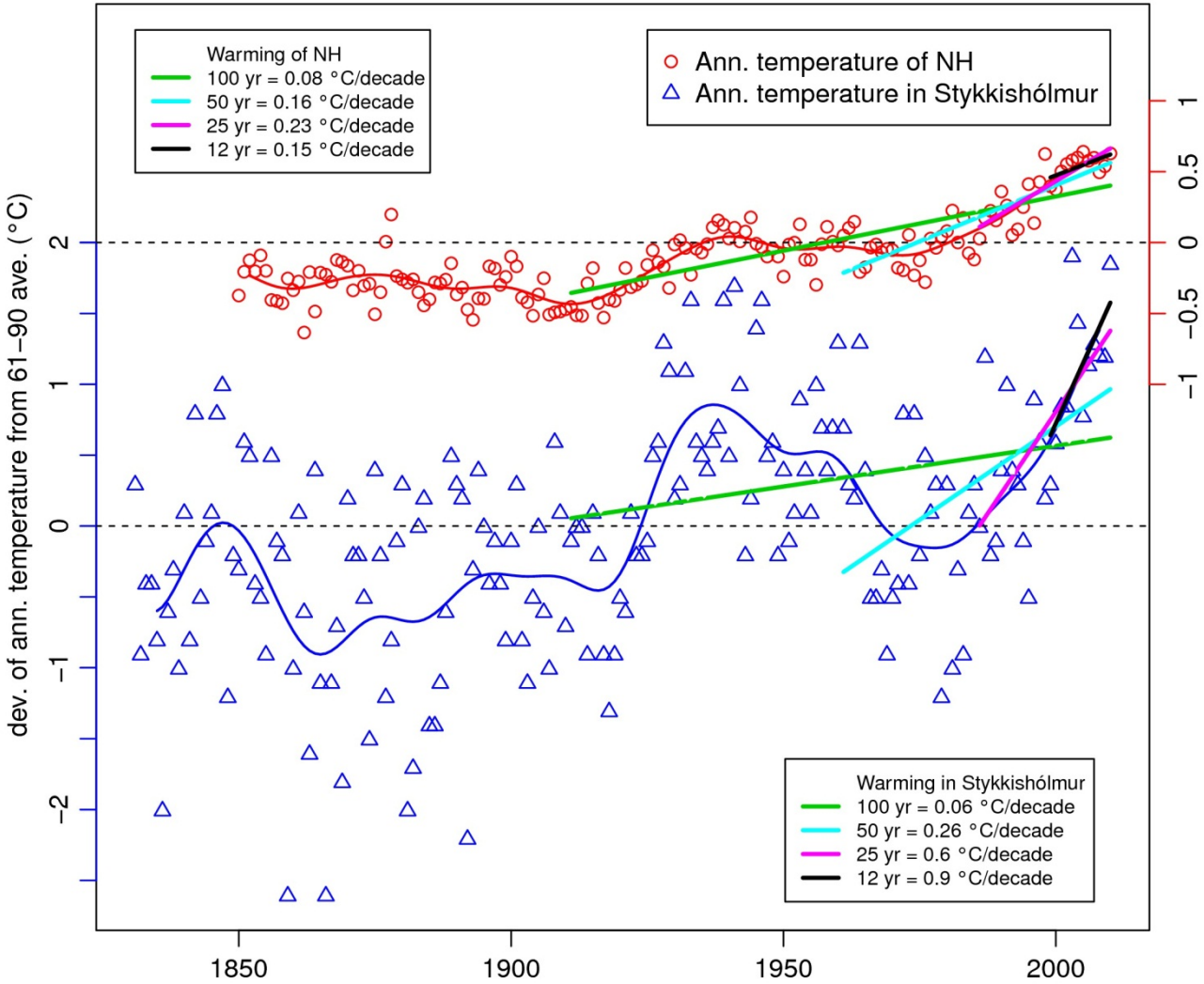

Temperature changes 1840-2010

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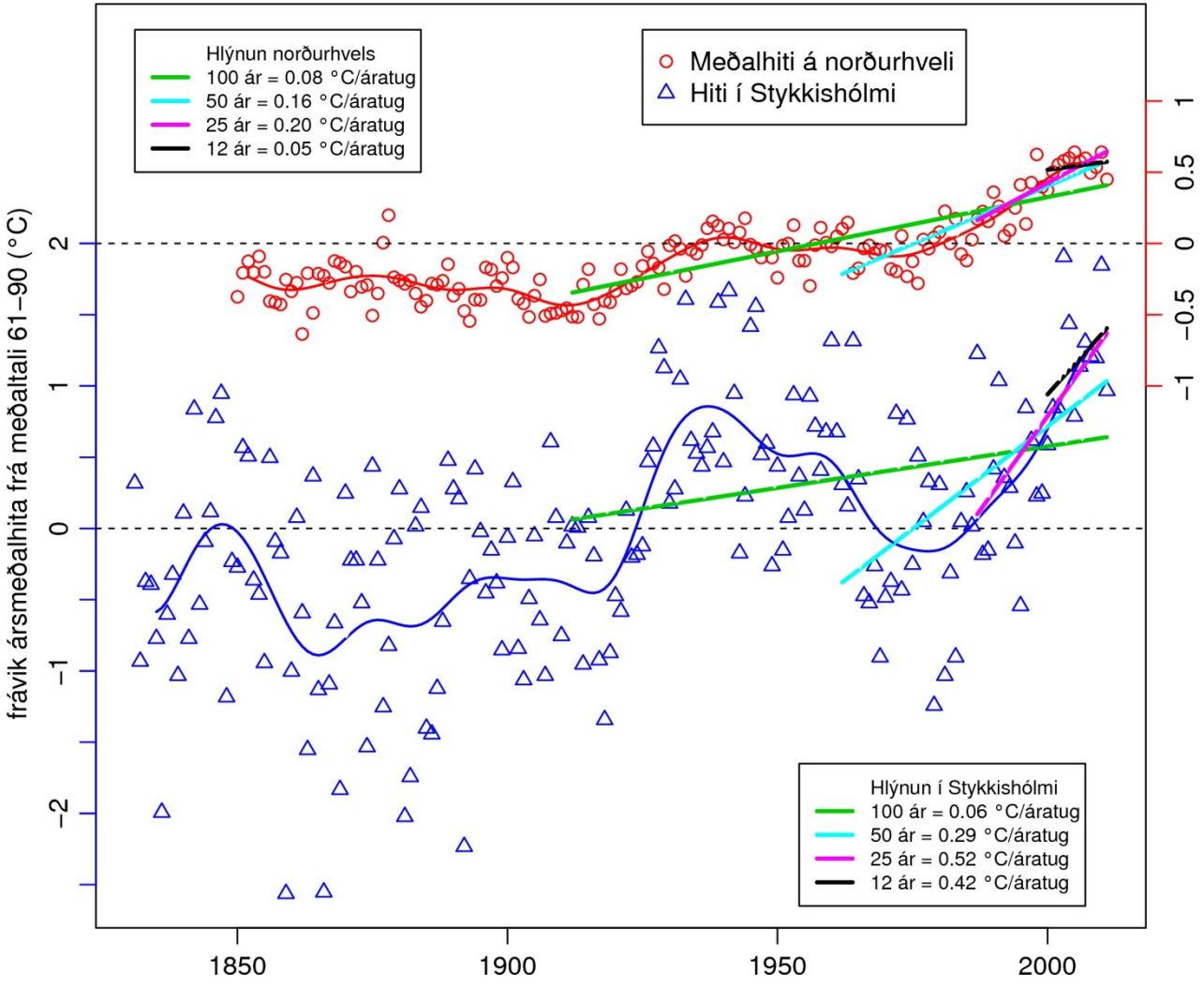
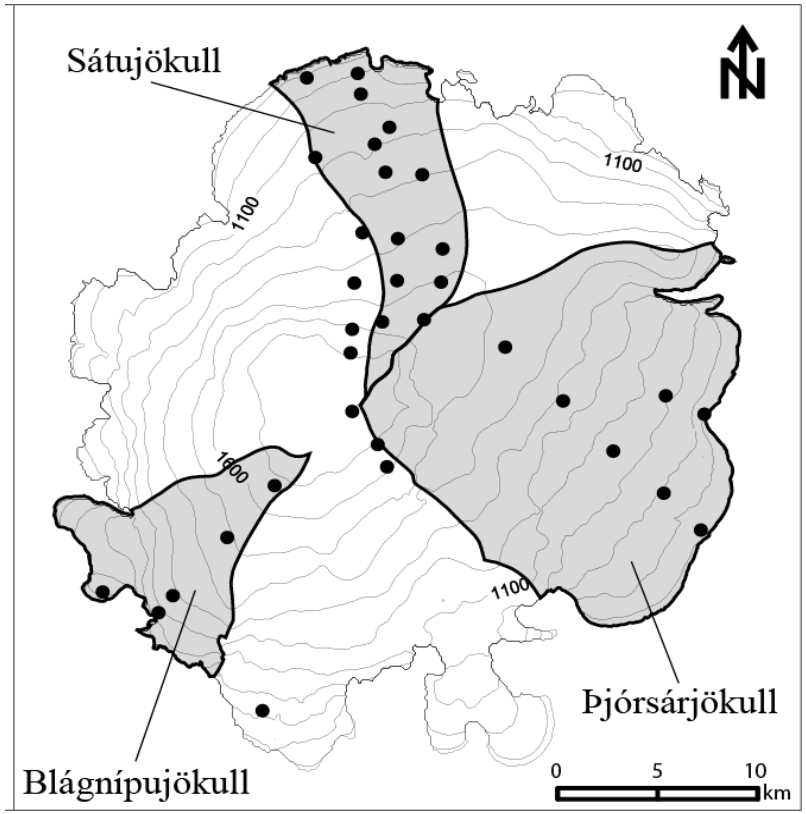
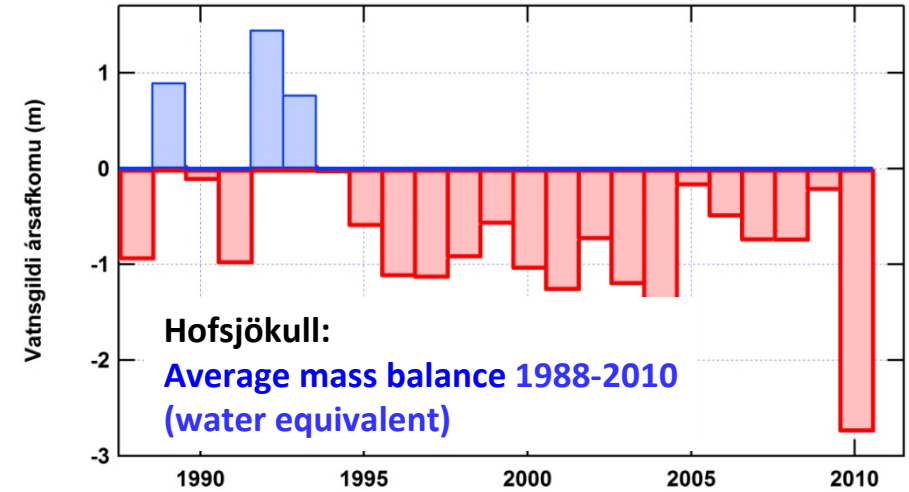
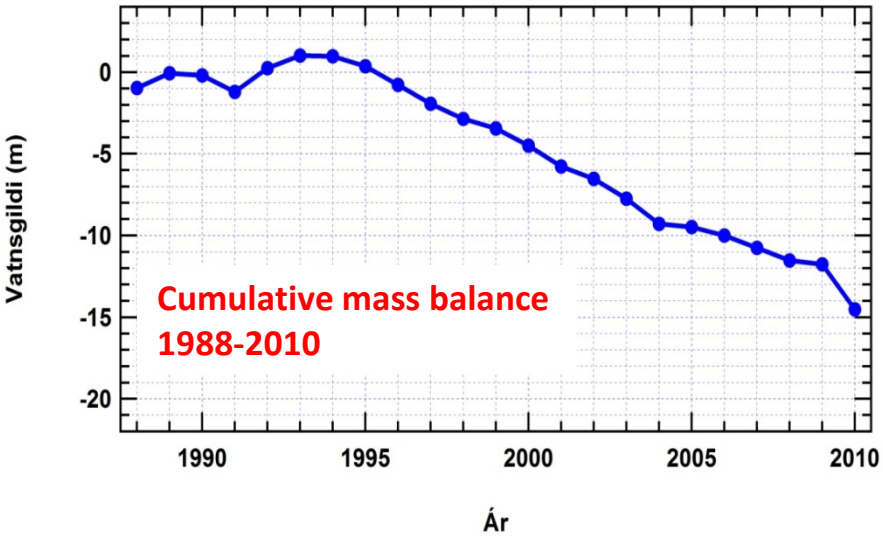


Hofsjökull mass balance 1988-2010



Locations of mass balance stakes





Hofsjökull volume change 1995-2010:

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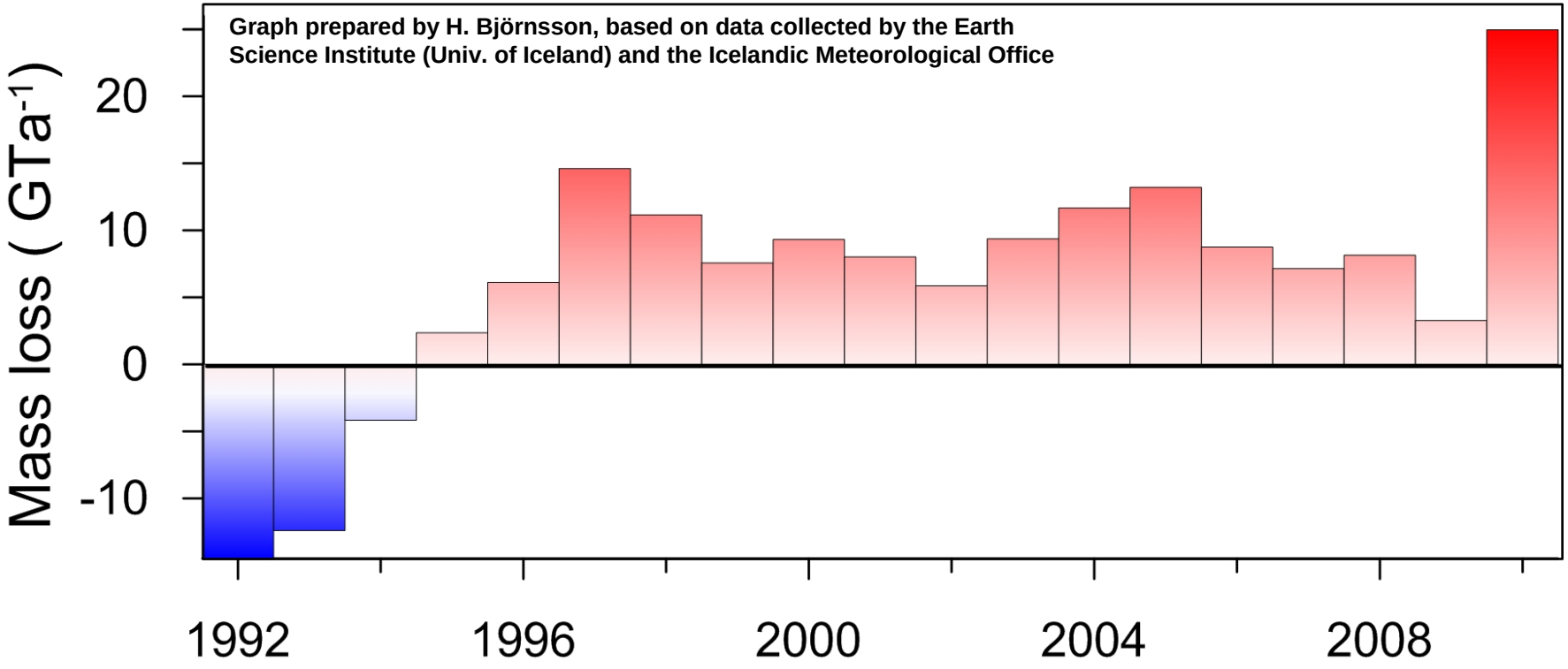
Basin		Mean annual balance 1995-2010	Volume loss 1995-2010
Sátujökull (80 km²)		÷1.0 m w.eq.	÷2 km³
Þjórsárjökull (230 km²)		÷0.8 m w.eq.	÷5 km³
Blágnípujökull (50 km²)		÷0.9 m w.eq.	÷1 km³

Total loss from measured basins (40% of ice cap): ÷ (8 ± 2) km³

==> Hofsjökull has lost roughly 20 km³ (10%) of its 1995 volume

Mass loss from glaciers in Iceland 1992-2010

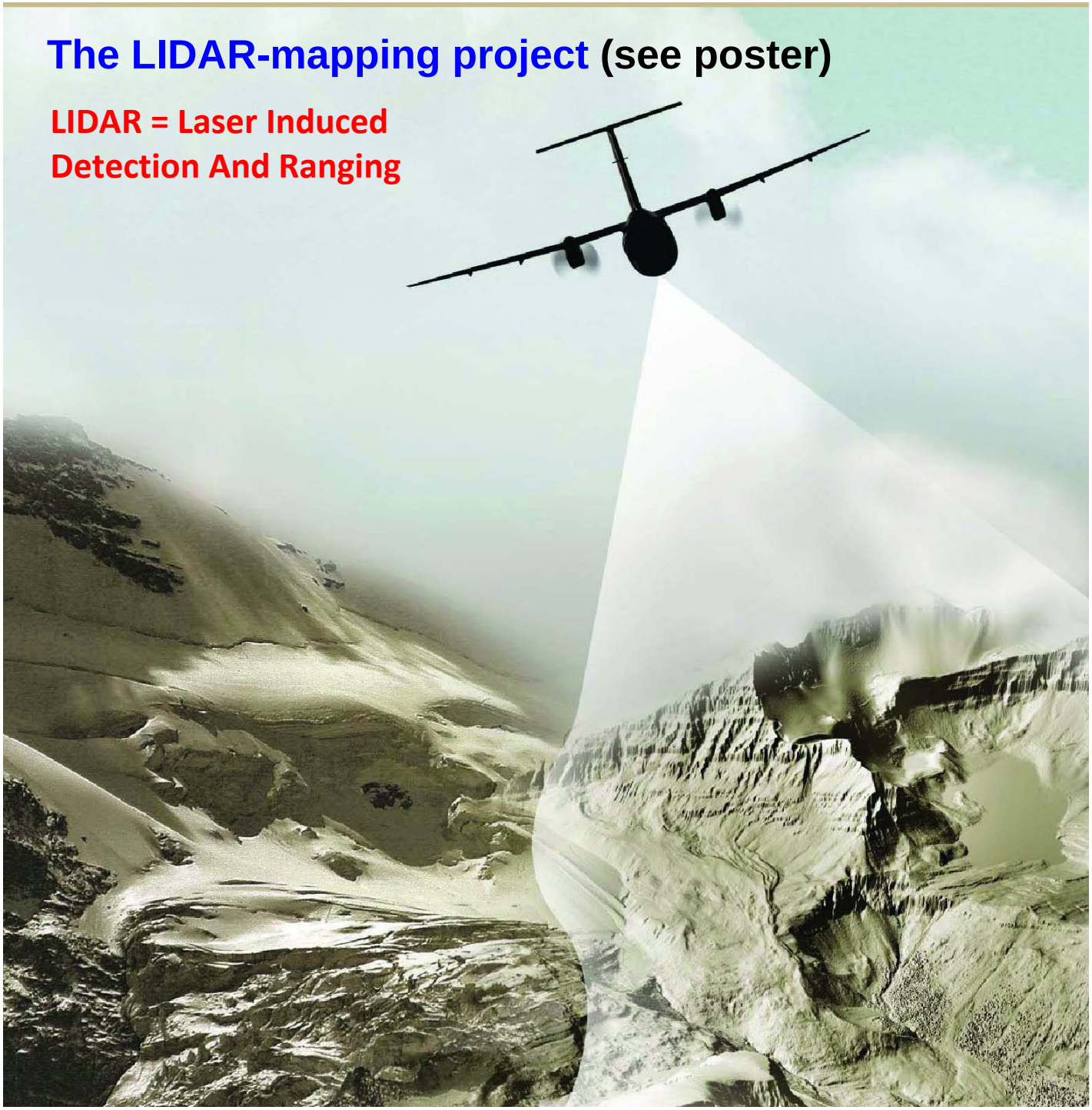


Negative mass balance every year since 1995!

The four large ice caps in Iceland are estimated to have lost 5-10% of their total 1995 volume in the period 1995-2011 (accuracy: ± 15%).

Extremely high mass loss 2010 due to ash deposition from Eyjafjallajökull

The LIDAR-mapping project (see poster)



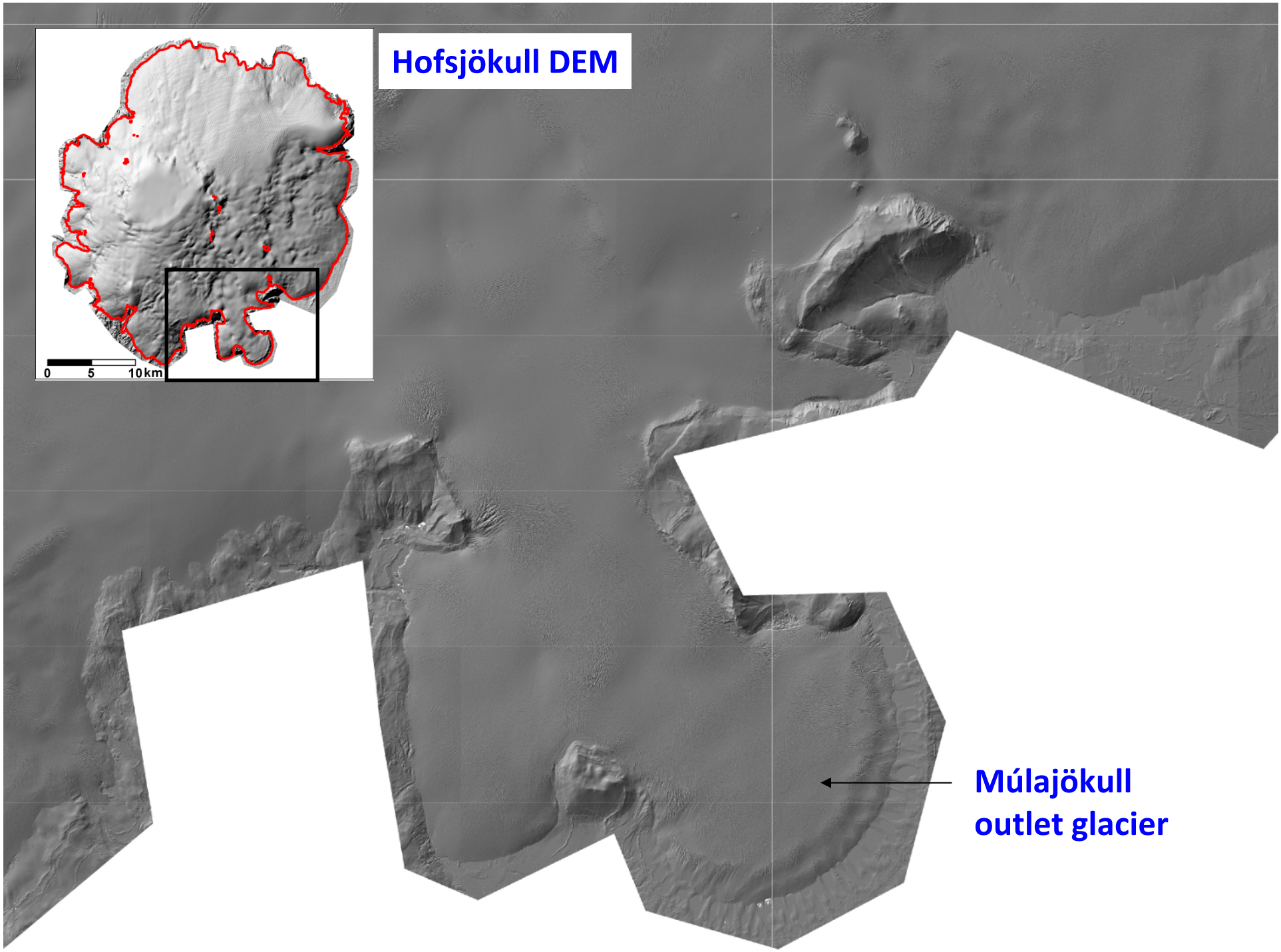
Glacier surfaces are mapped with *airborne laser scanning*.

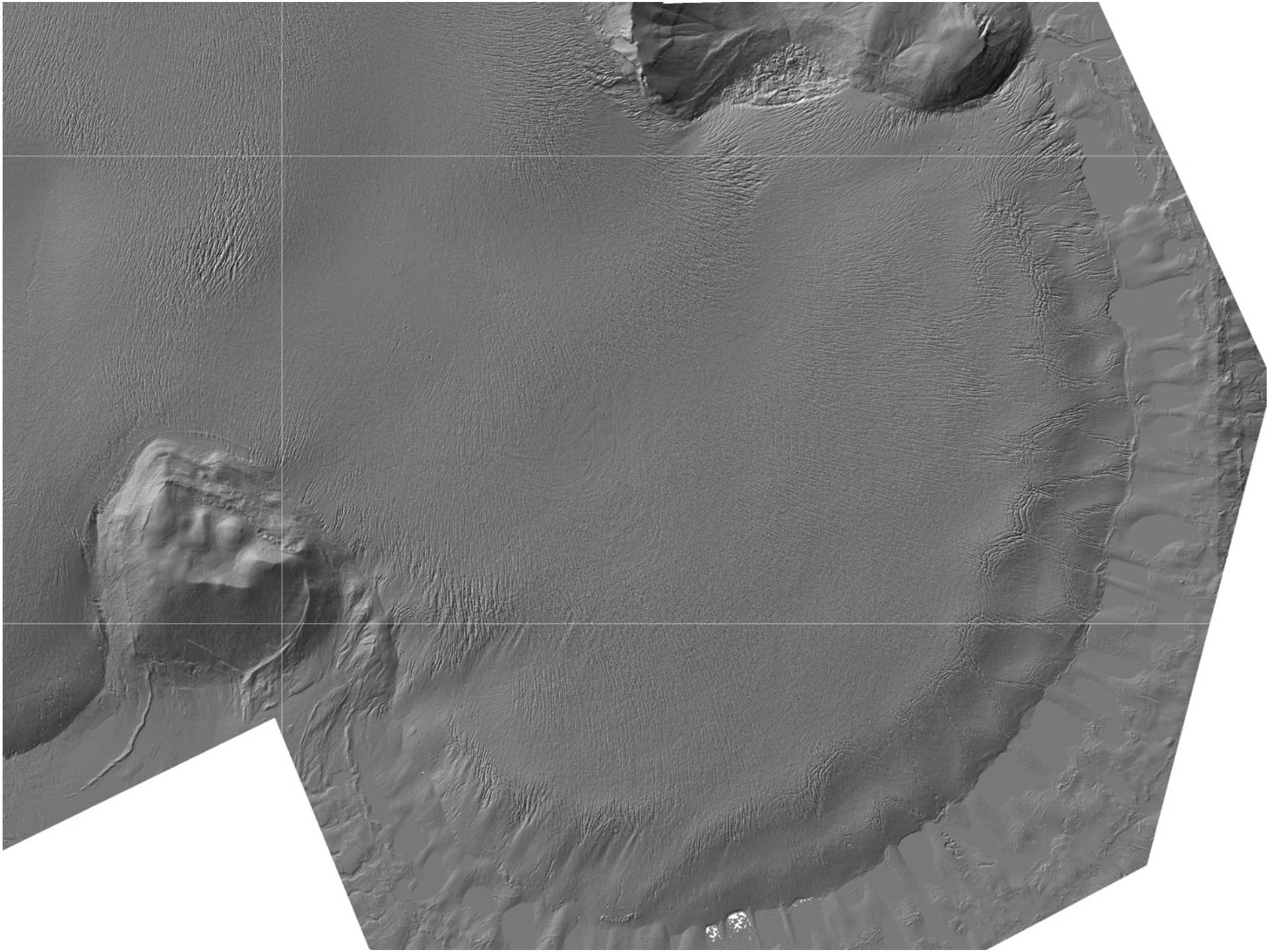
It relies on the combination of high-precision DGPS positioning in kinematic mode, inertial systems, and laser distance measurements.

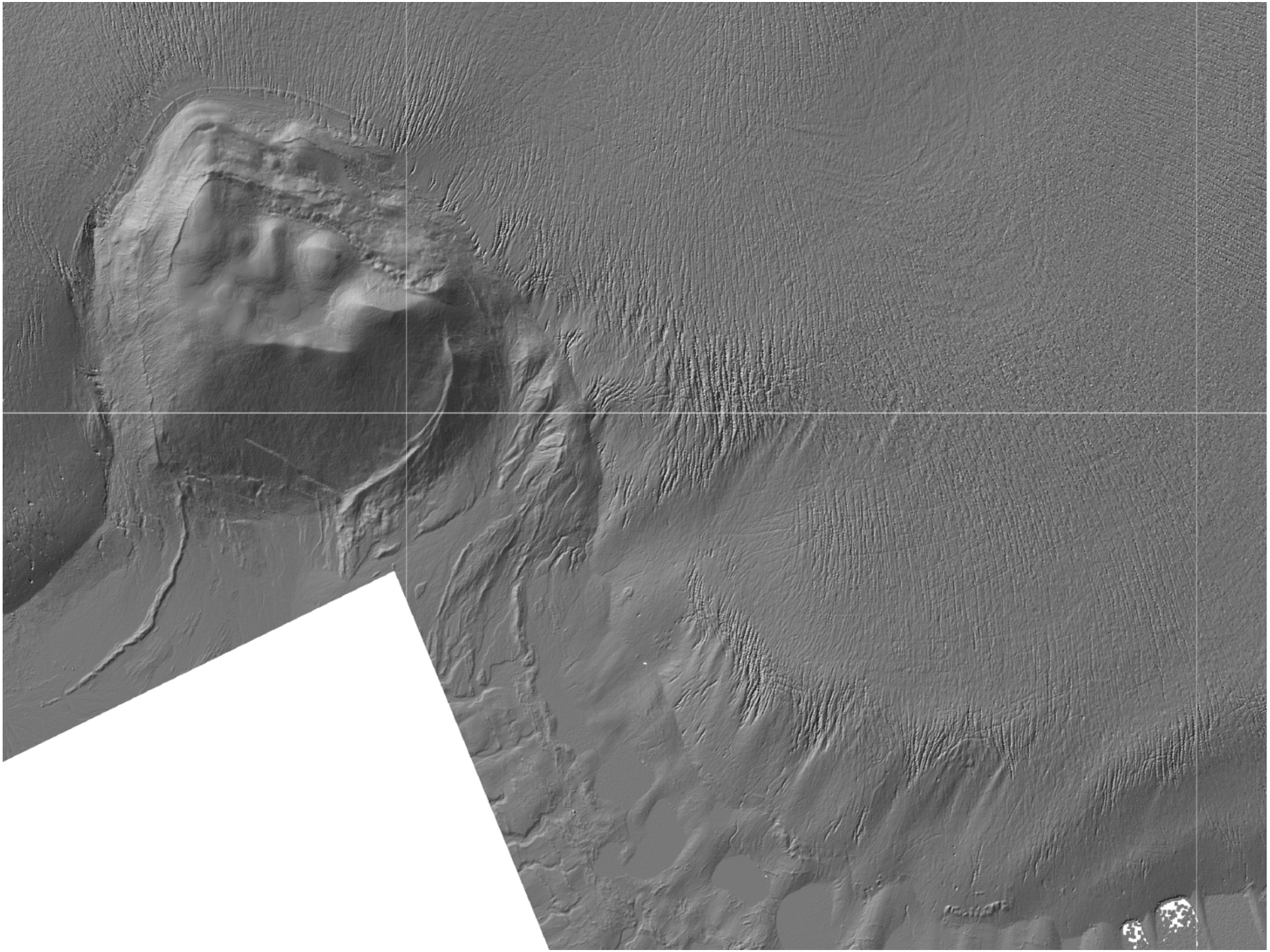
Accuracy in elevation measurement better than 0.5 m.

Project leader:
Dr. Tómas Jóhannesson
Icelandic Met. Office

Contractor:
TopScan, Stuttgart, Germany


Hofsjökull DEM
0
5
10 km
Múlajökull
outlet glacier





Elevation changes determined for Hofsjökull based on new LIDAR data and comparison with older maps and satellite images.

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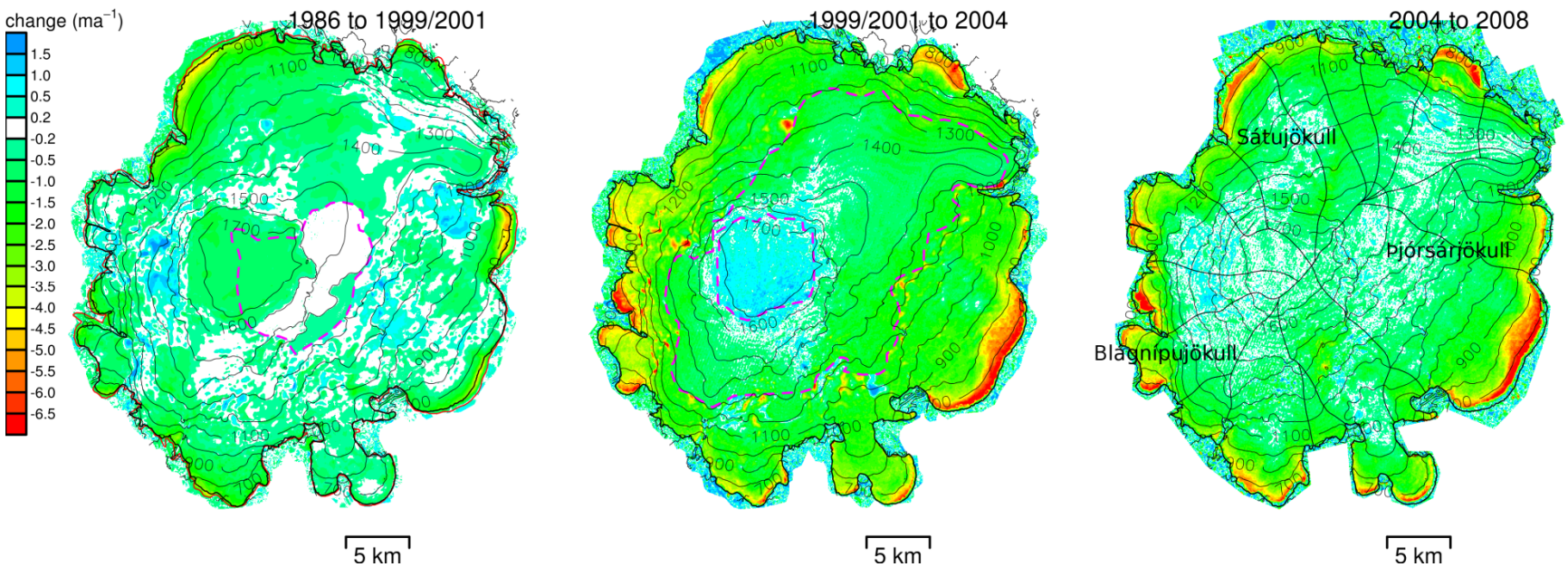

The LIDAR maps made from measurements of all major ice caps and glaciers in Iceland in 2008-2012 are benchmark results against which future changes in glacier surfaces and volumes will be measured.

A swift jökulhlaup originating within the Katla caldera occurred in the river Múlakvísl in the night of July 9 2011

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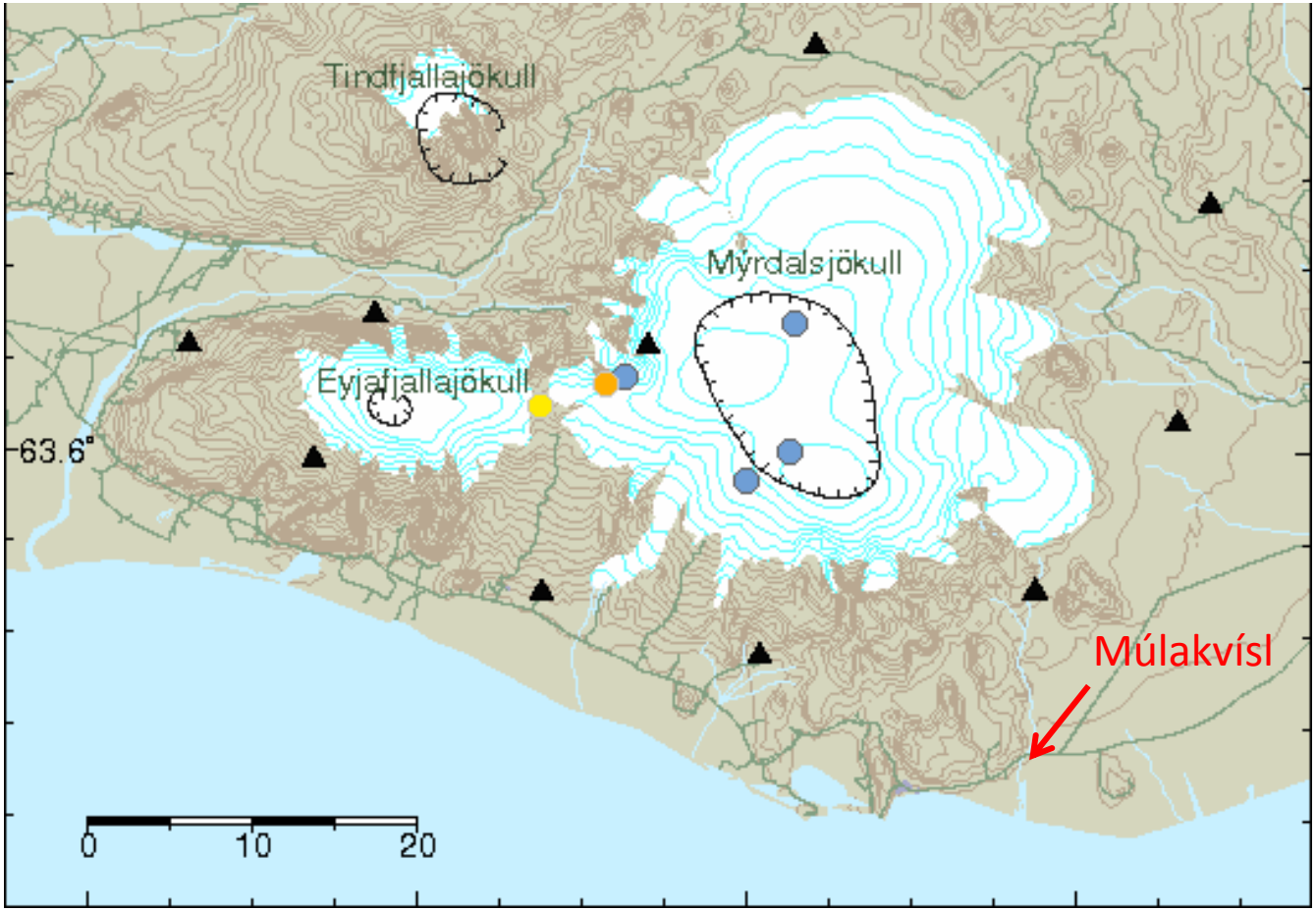
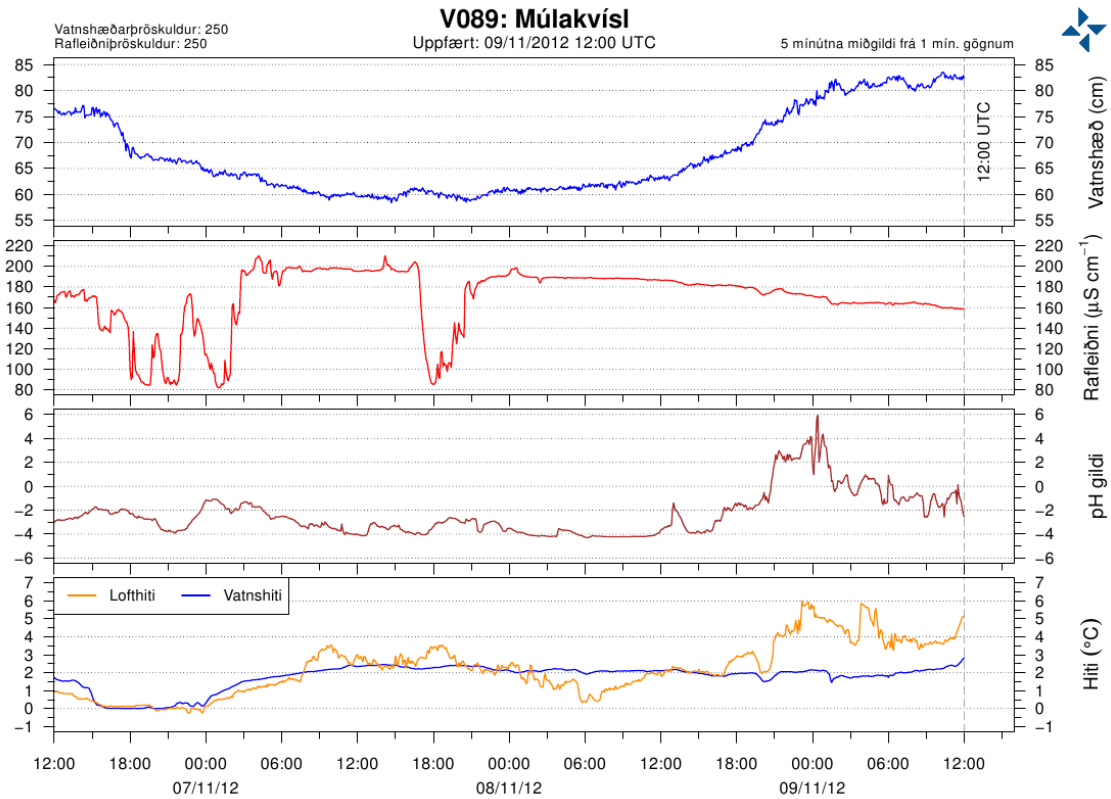


The volume of water released was estimated from repeated LIDAR measurements – see poster.

The bridge over Múlakvísl was swept away

A hydrometric station delivering real-time data disappeared



A new real-time hydrometric station with web camera

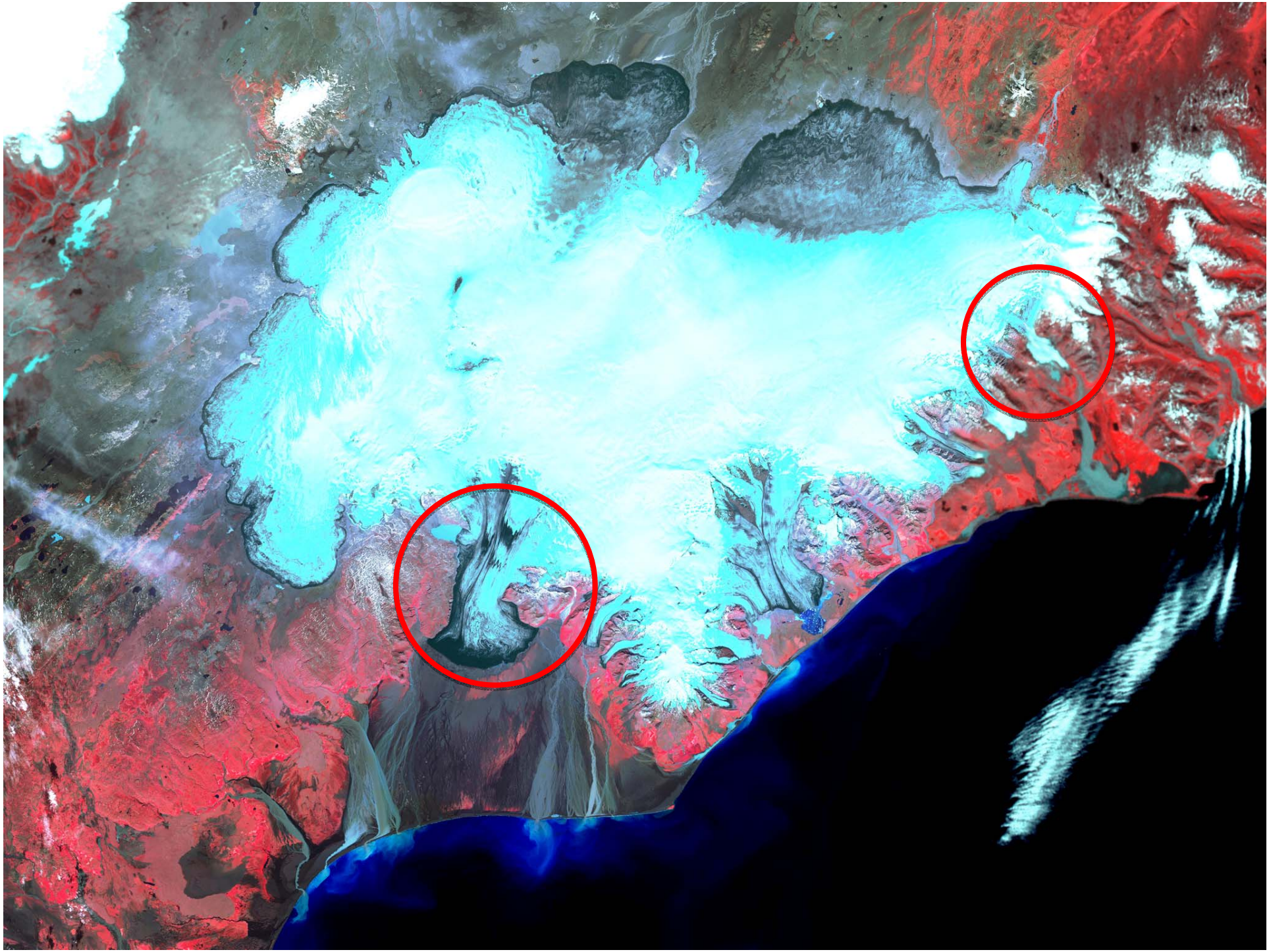
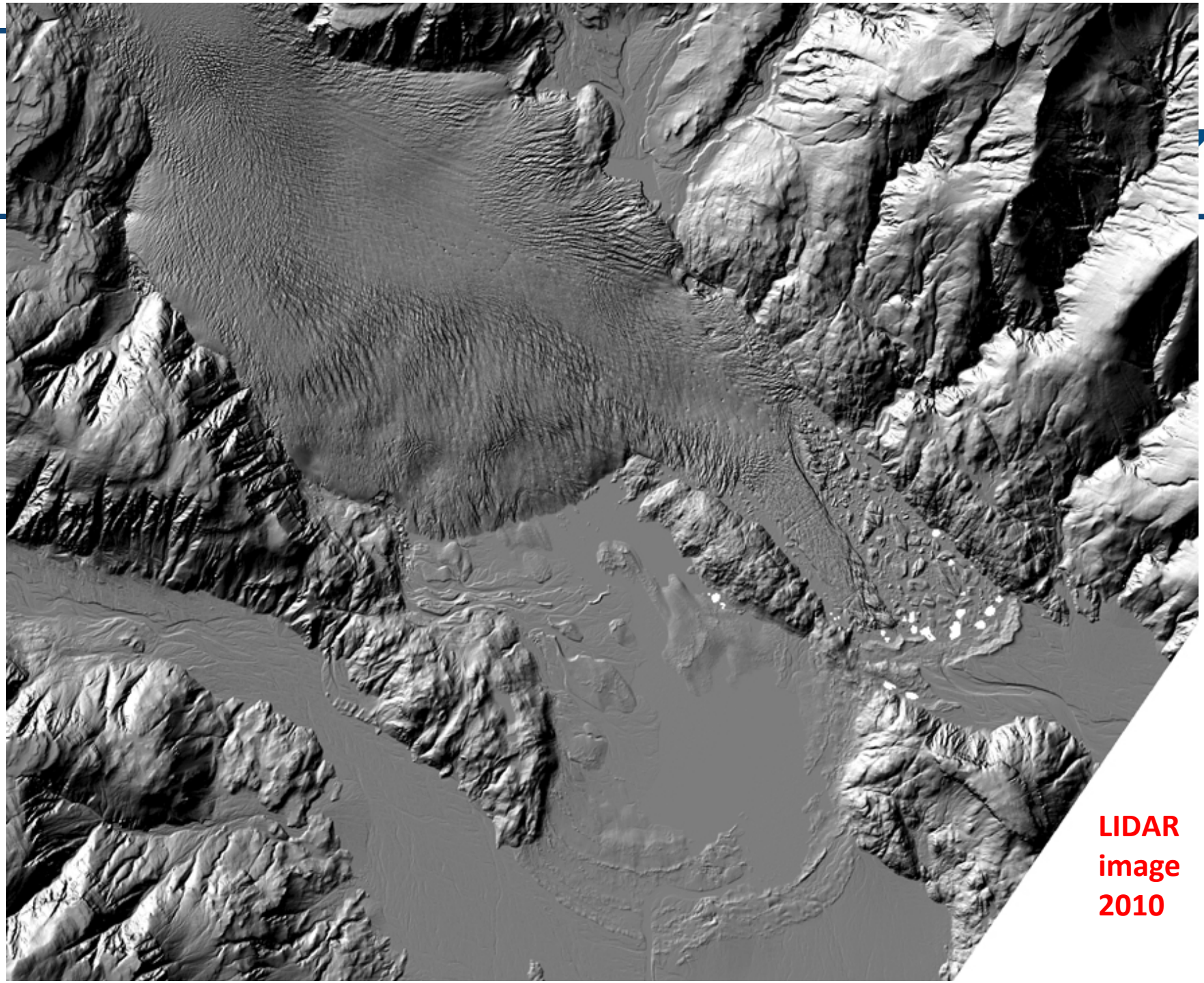


Photo from 2002. The easterly branch of the river stopped flowing in 2008, all meltwater from this glacier now enters the southern branch.


LIDAR
image
2010


N
Image IBCAO
© 2012 Cnes/Spot Image
Google earth
63°58'41.56" N 17°16'37.57" W elev 111 m
Eye alt 65.79 km

What kind of supersite structure could be built up in Iceland?

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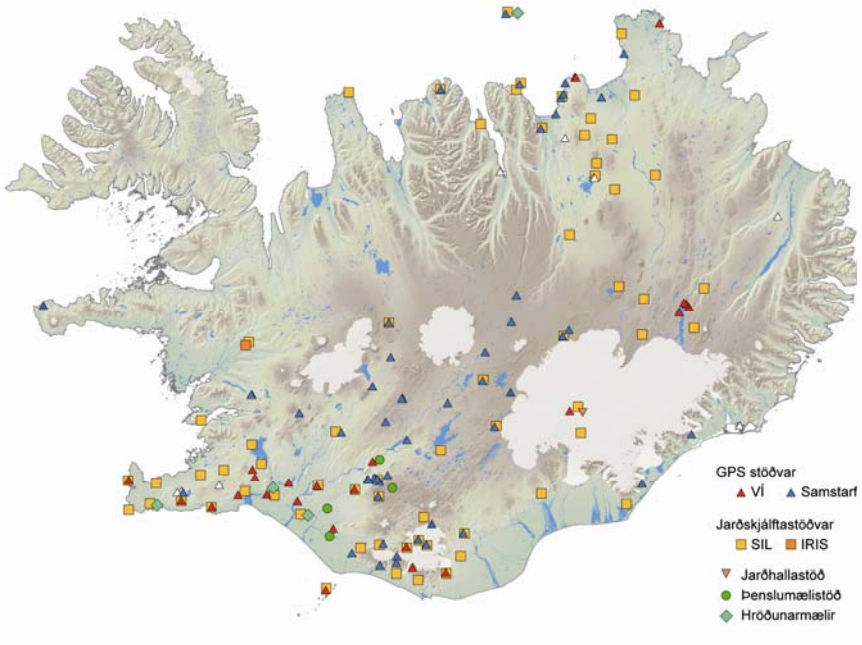
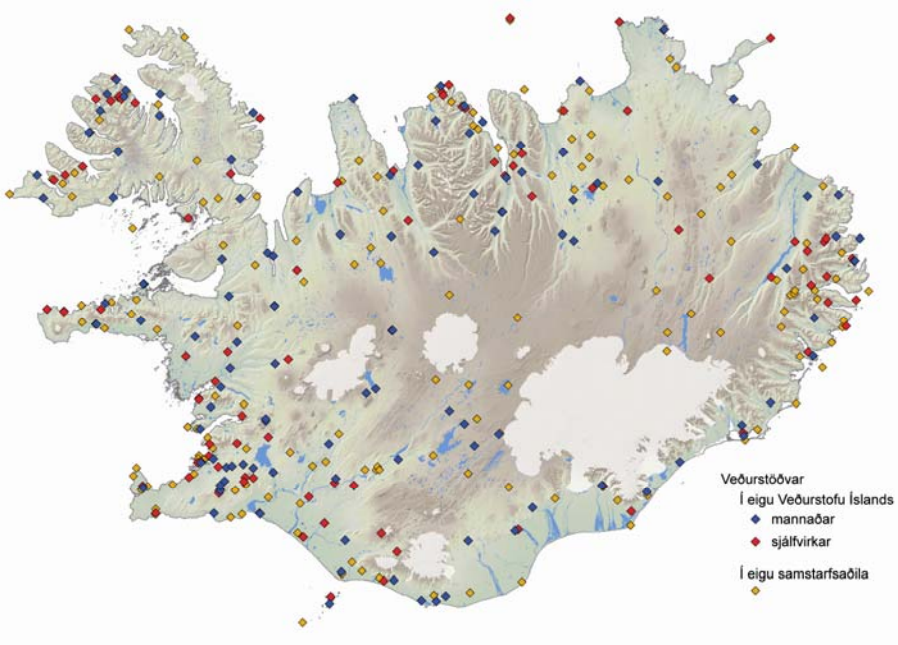
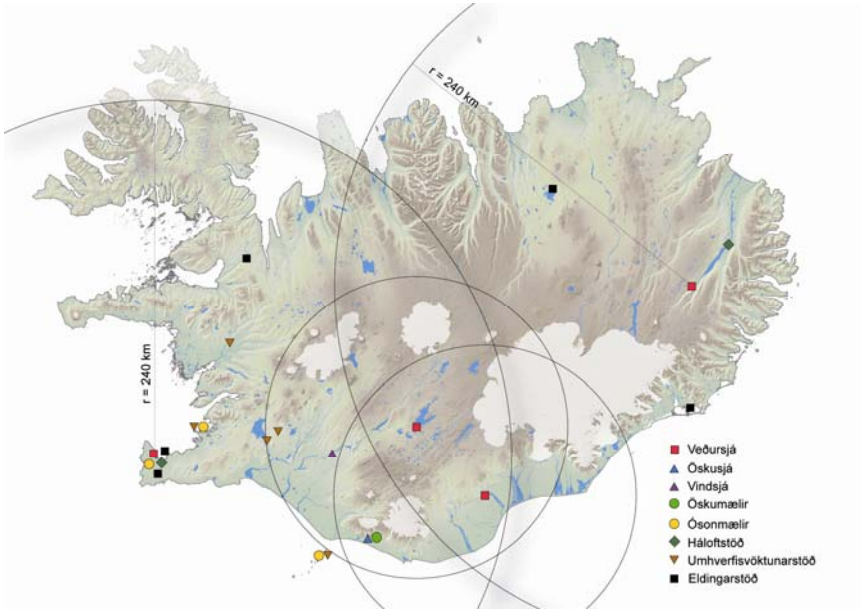
Ideas:

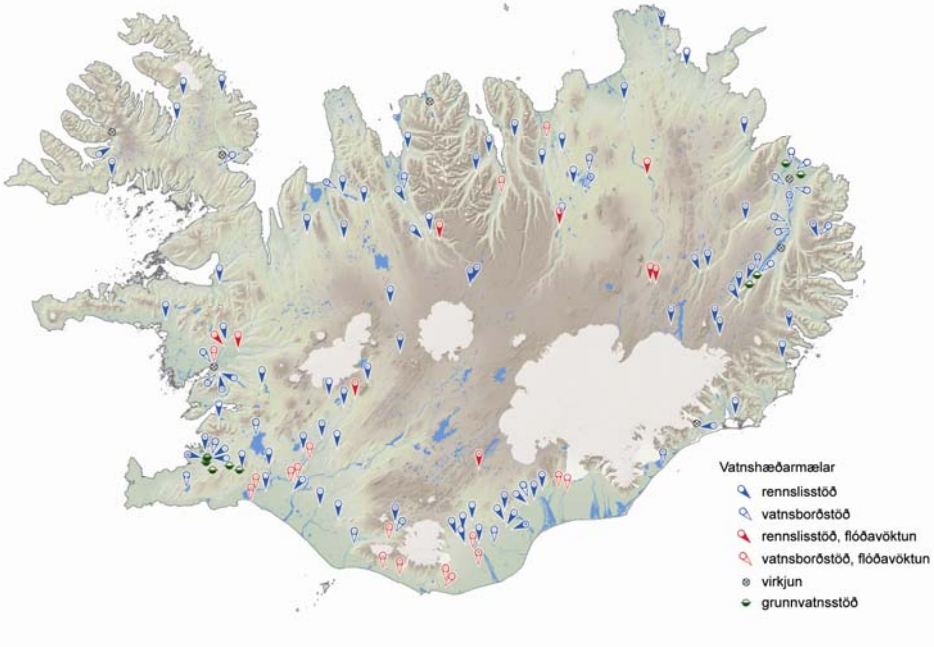
1. **Configure relevant parts of the existing (and upcoming) meteorological, hydrological and glaciological monitoring systems to serve GCW needs.**

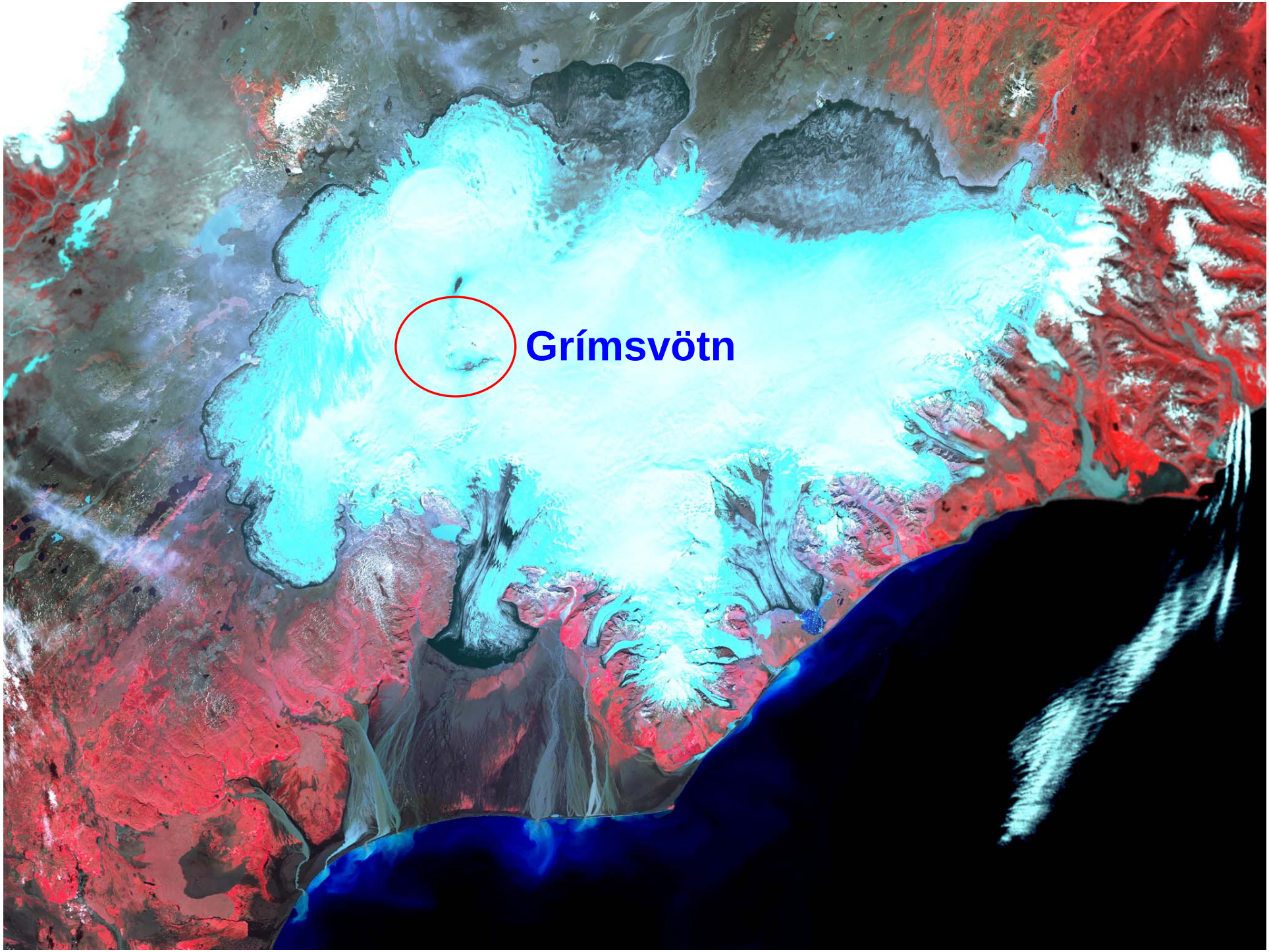
2. **Define an area of particular interest as a supersite, aim for targeted research. The Vatnajökull ice cap has been mentioned specifically in this respect.**


GPS stöðvar
VÍ
Samstarf
Jarðskjálftastöðvar
SIL
IRIS
Jarðhallastöð
Þenslumælistöð
Hröðunarmælir

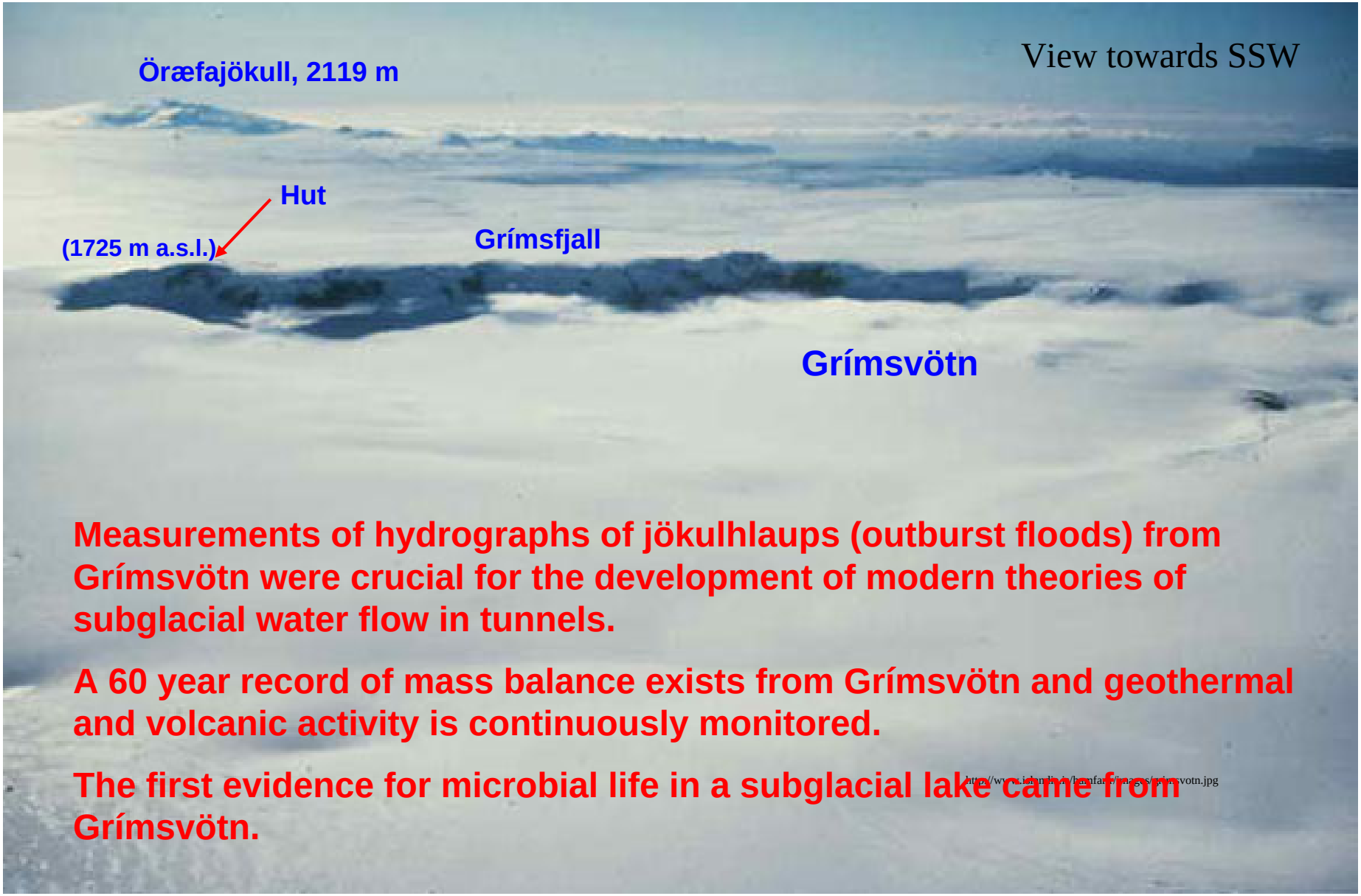

Veðurstöðvar
Í eigu Veðurstofu Íslands
mannaðar
sjálfvirkar
Í eigu samstarfsaðila


r = 240 km
r = 240 km
Veðursjá
Óskusjá
Vindsjá
Óskumælir
Ósonmælir
Háloftstöð
Umhverfisvöktunarstöð
Eldingarstöð


Vatnshæðarmælar
rennslisstöð
vatnsborðstöð
rennslisstöð, flóðavöktun
vatnsborðstöð, flóðavöktun
virkjun
grunnvatnsstöð


Grímsvötn

Grímsvötn – a ~40 km^2 subglacial lake within a volcanic caldera. Ice shelf thickness: ~250 m.

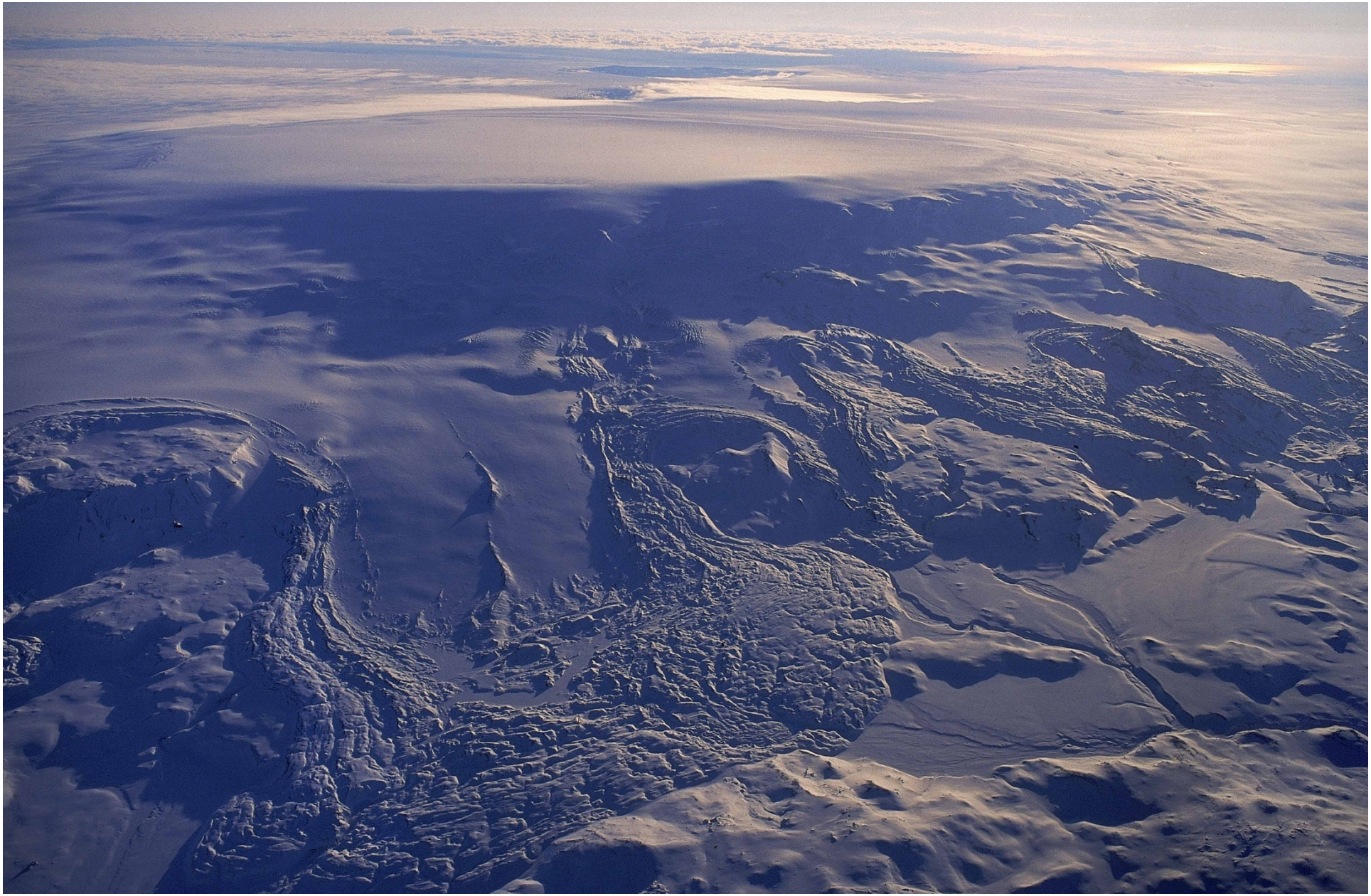


Measurements of hydrographs of jökulhlaups (outburst floods) from Grímsvötn were crucial for the development of modern theories of subglacial water flow in tunnels.

A 60 year record of mass balance exists from Grímsvötn and geothermal and volcanic activity is continuously monitored.

The first evidence for microbial life in a subglacial lake came from Grímsvötn.

http://www.jarnlist.is/hornfari/images/grimsvotn.jpg



Ice-filled Bárðarbunga volcanic caldera, NW Vatnajökull

Photo: Oddur Sigurðsson