A supersite for cryospheric studies in Iceland?

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MODIS Satellite image of Iceland almost entirely covered with snow
The cryosphere in Iceland

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
Vatnajökull (8000 km²)

Hofsjökull (870 km²)

Langjökull (900 km²)

Drangajökull (160 km²)

Mýrdalsjökull (550 km²)

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

- Total area: ~11,000 km²
- Total volume: ~3600 km³
- 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

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

Katla

Photo: Oddur Sigurðsson
Rapid retreat of ice margins (20-50 m annually) since 1995.

Each year, ~20 km² of new, previously ice-covered land is exposed in Iceland.
Temperature changes 1840-2006
Temperature changes 1840-2010
Hofsjökull mass balance 1988-2010

Locations of mass balance stakes

Hofsjökull: Average mass balance 1988-2010 (water equivalent)

Cumulative mass balance 1988-2010
### Hofsjökull volume change 1995-2010:

<table>
<thead>
<tr>
<th>Basin</th>
<th>Mean annual balance 1995-2010</th>
<th>Volume loss 1995-2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sátujökull</td>
<td>÷1.0 m w.eq.</td>
<td>÷2 km³</td>
</tr>
<tr>
<td>(80 km²)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Þjórsárjökull</td>
<td>÷0.8 m w.eq.</td>
<td>÷5 km³</td>
</tr>
<tr>
<td>(230 km²)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blágnípujökull</td>
<td>÷0.9 m w.eq.</td>
<td>÷1 km³</td>
</tr>
<tr>
<td>(50 km²)</td>
<td></td>
<td></td>
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</tbody>
</table>

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
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

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

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.

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

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.
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GPS stöðvar
- VI
- Samstari

Jafnbjásthroðvar
- SIL
- IRS

Jafnhallastöð
- Ísland

Minnunastöð
- Hrobúnamæli

Vatnshæðarmæli
- Rennisárlitöö
- Vatnshöfðingö
- Vatnshöfðingö, Íhöfðingö
- Vatnshöfðingö, Íhöfðingö, vörðunum
- vörðunum
- grunvatnastöð
Grímsvötn
Grímsvötn – a ~40 km² 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.
Ice-filled Bárðarbunga volcanic caldera, NW Vatnajökull

Photo: Oddur Sigurðsson