Icelandic Met Office

Icelandic Met Office

Landslide monitoring system in Iceland

Harpa Grímsdóttir

Jón Kristinn Helgason

NVE, Oslo, October 26 2016

History

Icelandic Met Office

Avalanches and landslides have caused extensive damages and loss of human lives in Iceland

Avalanches are responsible for a greater number of deaths than landslides

Avalanches have caused bigger accidents than landslides with higher number of casualties in single events

The difference is probably smaller in terms of economical losses

Avalanche accidents in 1995

Icelandic Met Office

In 1995 34 people lost their lives in two avalanche disasters in the Westfjords of Iceland

- 14 in Súðavík in January
- 20 in Flateyri in October

The year 1995 became a turning point for avalanche work in Iceland and landslides as well

„Ofanflóð" is a term that includes both avalanches and landslides

After 1995

After 1995, new hazard mapping criteria was developed as well as new methods.

- Hazard maps are made for „ofanflóð“ (landslides and avalanches)

Municipalities that have red zones within urban areas are required to take action

- Buy living houses or defend them permanently

The monitoring system was reorganised

The national avalanche and landslide fund was strengthened

- Pays for 90% of defence structures, hazard mapping and some research

Monitoring role of IMO

The Icelandic Meteorological Office (IMO) has the overall responsibility of monitoring natural hazards in Iceland

For avalanches and landslides IMO has a special role of monitoring settlements

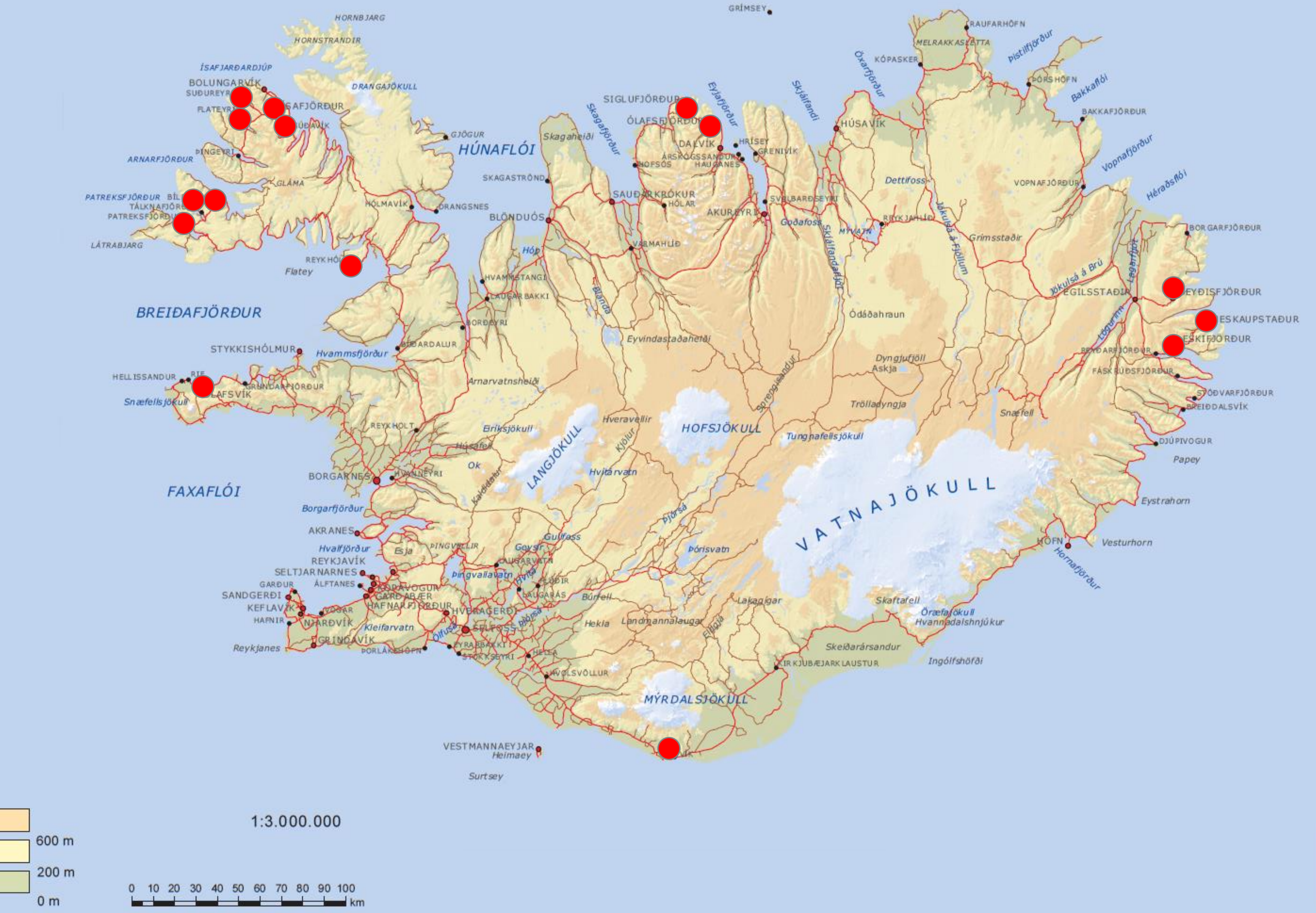
- For avalanches, IMO orders evacuation of houses during periods of high danger
- For landslides, IMO advises local authorities and civil protection about evacuations and other actions

Monitoring system at IMO

Icelandic Met Office

Landslide and avalanche monitoring shifts

- 7 people in three different offices of IMO: Ísafjörður, Akureyri, Reykjavík
  - One week on duty
  - More people on duty when the danger rises
- 20 snow observers around the country
  - Also help with evaluation of landslide risk
  - Monitor individual paths
- Good cooperation with national and local civil authorities
- Daily meetings with meteorologists and natural hazard specialists on duty
  - Civil authorities included during periods of increased danger



HORNBJARG
HORNSTRANDIR
ÍSAFJARÐARDJÚP
BOLUNGARVÍK
SUÐUREYRI
FLATEYRI
DRANGAJÖKULL
GJÖGUR
ÞINGEYRI
ARNARFJÖRÐUR
GLÁMA
PATREKSFJÖRÐUR
TÁLKNAFJÖRÐUR
LÁTRABJARG
HÓLMAVÍK
DRANGSNES
Flatey
BREIÐAFJÖRÐUR
STYKKISHÓLMUR
Hvammsfjörður
HELLISSANDUR
RIF
GRUNDARFJÖRÐUR
Snæfellsjökull
BÚÐARDALUR
BORÐEYRI
REYKHOLT
BORGARNES
HVANNEYRI
FAXAFLÓI
Borgarfjörður
AKRANES
Hvalfjörður
Esja
REYKJAVÍK
SELTJARNARNES
ÁLFTANES
GARÐUR
SANDGERÐI
KEFLAVÍK
HAFNIR
NJARÐVÍK
VOGAR
KÓPAVOGUR
GARÐABÆR
HAFNARFJÖRÐUR
GRINDAVÍK
Kleifarvatn
Reykjanes
ÞORLÁKSHÖFN
Ölfusá
HVERAGERÐI
SELFOSS
EYRARBAKKI
STOKKSEYRI
HELLA
HVOLSVÖLLUR
VESTMANNAEYJAR
Heimaey
Surtsey
ÞINGVELLIR
Þingvallavatn
LAUGARVATN
Geysir
Gullfoss
FLÚÐIR
LAUGARÁS
Búrfell
Hekla
Landmannalaugar
MÝRDALSJÖKULL
HÚNAFLÓI
SKAGASTRÖND
BLÖNDUÓS
Hóp
HVAMMSTANGI
LAUGARBAKKI
Arnarvatnsheiði
Eiríksjökull
Húsafell
Ok
Kaldidalur
LANGJÖKULL
Hveravellir
Kjölur
Hvítárvatn
HOFSJÖKULL
Eyvindastaðaheiði
Blanda
Skagaheiði
Skagafjörður
SAUÐÁRKRÓKUR
HÓLAR
VARMAHLÍÐ
SIGLUFJÖRÐUR
HOFSÓS
DALVÍK
ÁRSKÓGSSANDUR
HAUGANES
HRÍSEY
GRENIVÍK
Eyjafjörður
AKUREYRI
SVALBARÐSEYRI
GRÍMSEY
Goðafoss
Skjálfandafljót
Skjálfandi
HÚSAVÍK
Dettifoss
MÝVATN
REYKJAHLÍÐ
Jökulsá á Fjöllum
Öxarfjörður
KÓPASKER
MELRAKKASLÉTTA
RAUFARHÖFN
Þistilfjörður
ÞÓRSHÖFN
Bakkaflói
BAKKAFJÖRÐUR
Vopnafjörður
VOPNAFJÖRÐUR
Héraðsflói
BORGARFJÖRÐUR
Grímsstaðir
Jökulsá á Brú
Lagarfljót
EGILSSTAÐIR
Lögurinn
Ódáðahraun
Dyngjufjöll
Askja
Sprengisandur
Trölladyngja
Tungnafellsjökull
Snæfell
REYÐARFJÖRÐUR
FÁSKRÚÐSFJÖRÐUR
STÖÐVARFJÖRÐUR
BREIÐDALSVÍK
DJÚPIVOGUR
Papey
Eystrahorn
VATNAJÖKULL
Þjórsá
Þórisvatn
Lakagígar
Eldgjá
Skaftafell
Öræfajökull
Hvannadalshnjúkur
HÖFN
Hornafjörður
Vesturhorn
Skeiðarársandur
KIRKJUBÆJARKLAUSTUR
Ingólfshöfði
1:3.000.000
600 m
200 m
0 m
0 10 20 30 40 50 60 70 80 90 100 km

Warnings and dissemination

Focus on settlements

- Uncertainty Phase
- Alert Phase
  - Evacuation of houses

Local knowledge is important

In recent years more emphasis has been put on regional warnings during heavy rain and/or runoff events

- Floods and landslides
- Press releases and banner on the front page of IMO´s website: vedur.is
  - More details on the hydrology part of the web site
- A color coded system for displaying regional warnings will be put to use this winter for weather, floods and landslides. Other types of natural hazards added later.

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Tue 25 Oct

Warnings:

Yellow	Amber	Red					
Be aware	Be prepared	Take action	Rain	Wind	Snow	Ice	Fog

Data for monitoring

Central national database for landslides

Weather forecast

- Harmonie NWP model
  - Precipitation, temperature, wind speed and direction
  - Runoff output (accumulated rain + snowmelt)

Weather data

- Manual observations
- Automatic weather stations
  - Precipitation
  - Temperature
  - Snow depth and snow temperature
  - Wind speed and direction

Discharge values

Recorded landslides in Iceland

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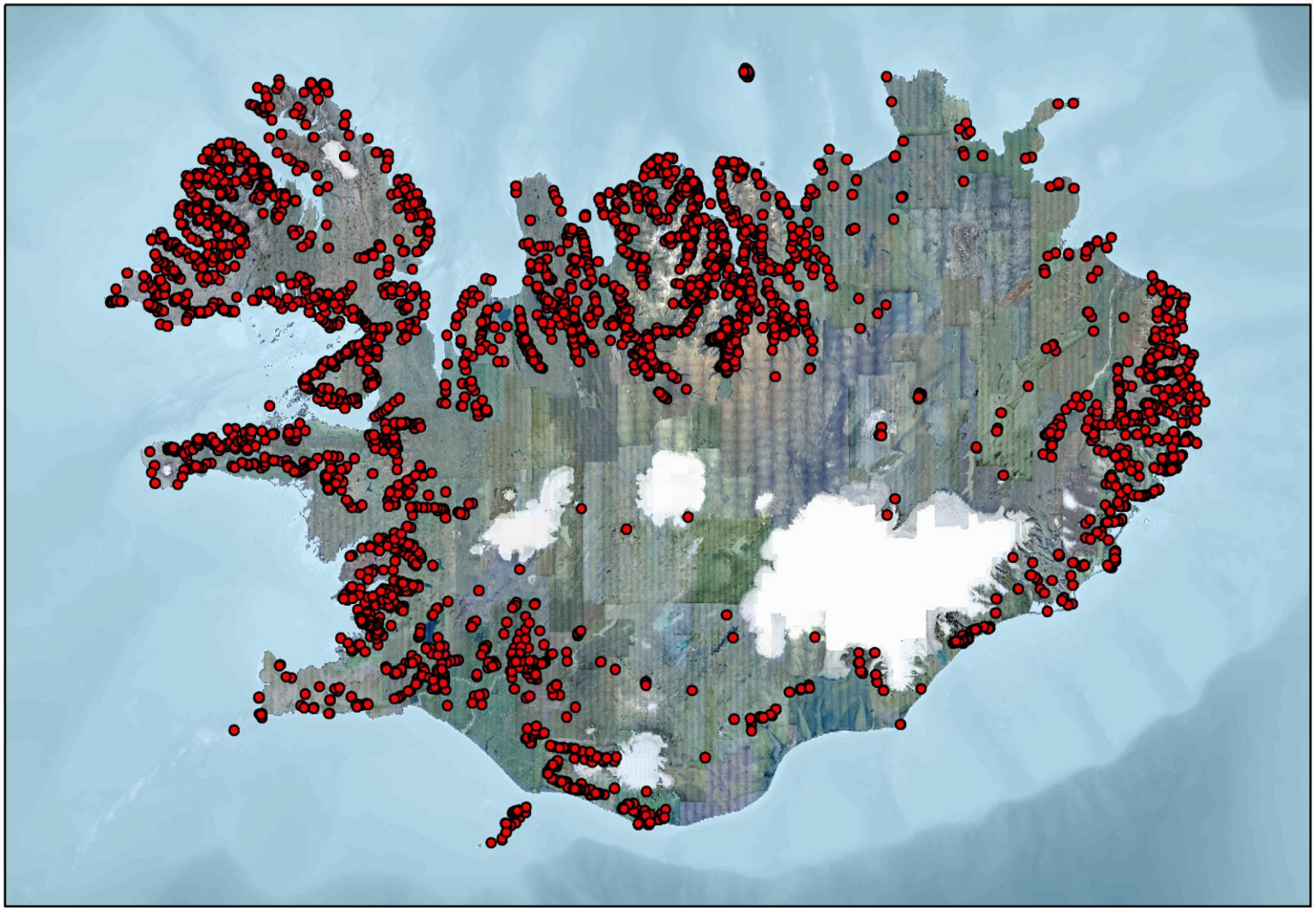
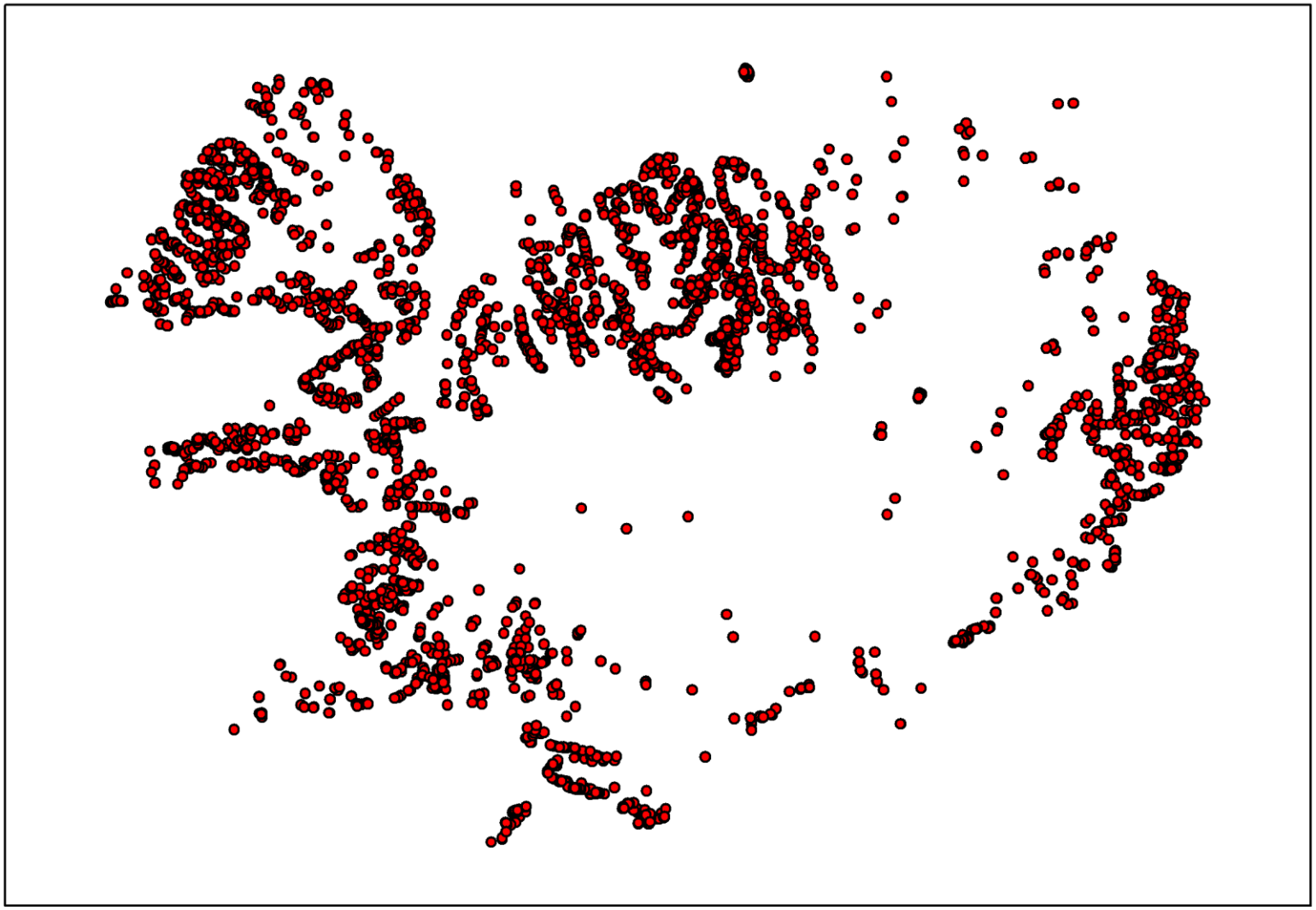


Landslides in Iceland

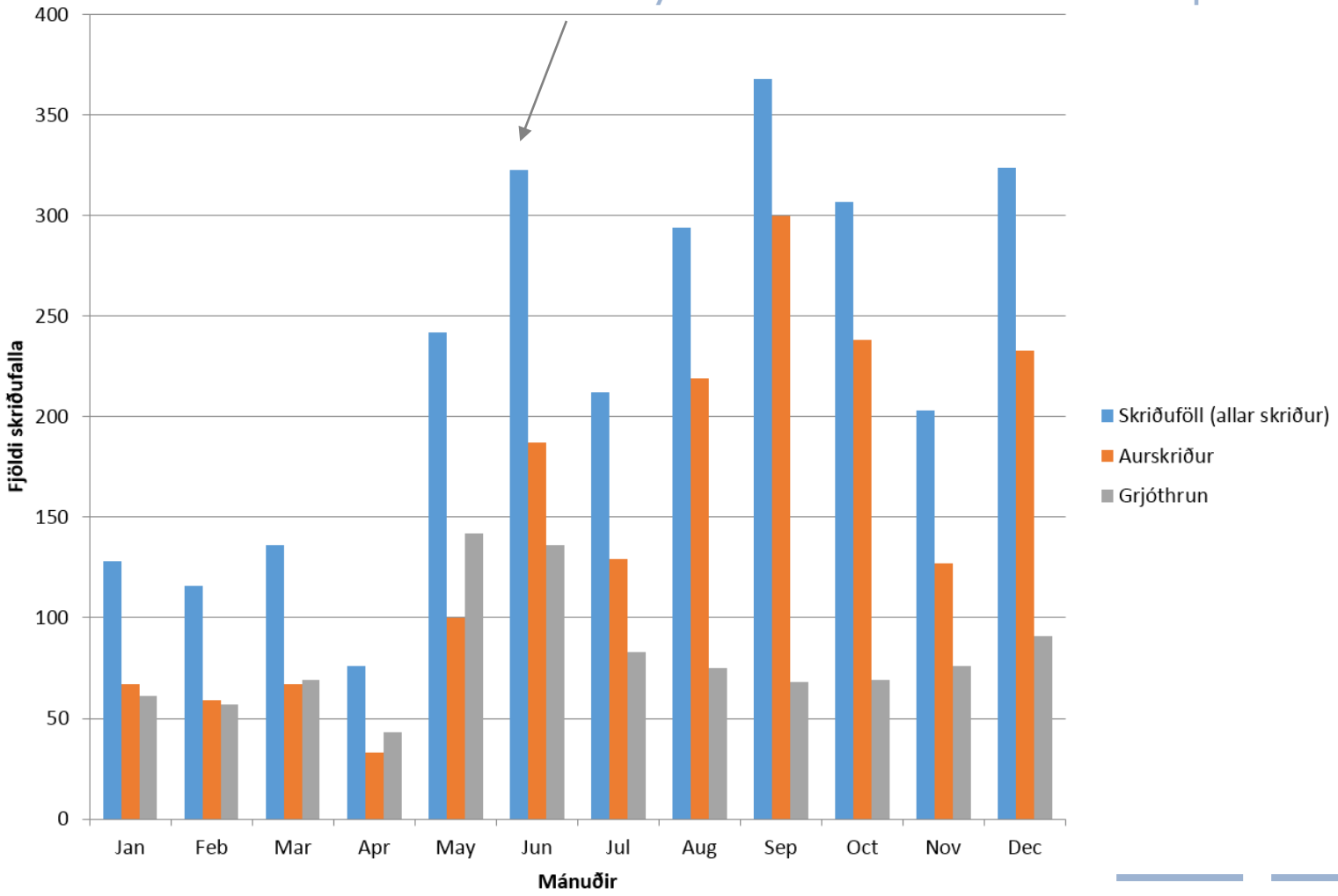
Icelandic Met Office



Landslides in Iceland by months

From 1900 until 2011

Many landslides due to earthquakes



Precipitation measurements

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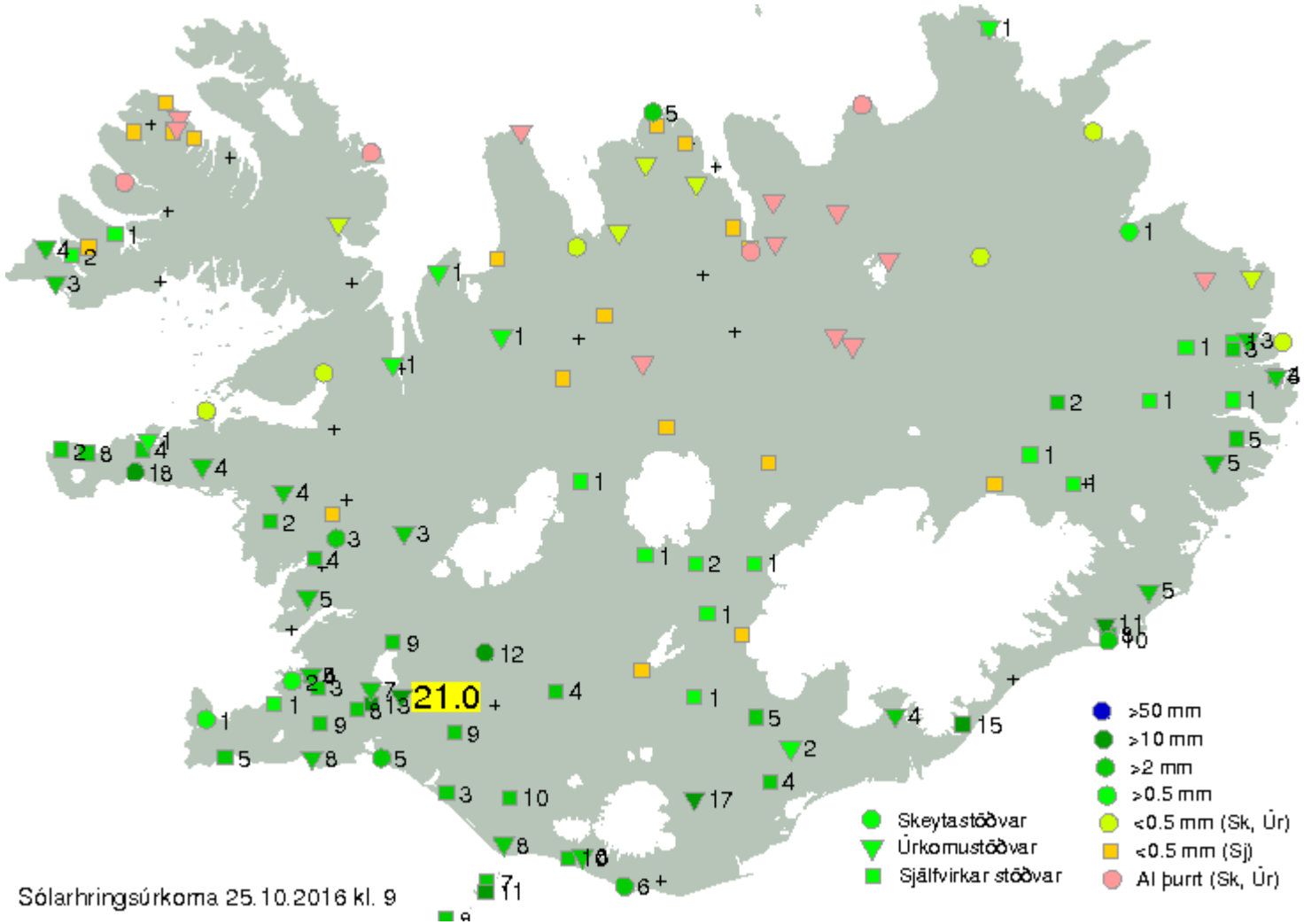
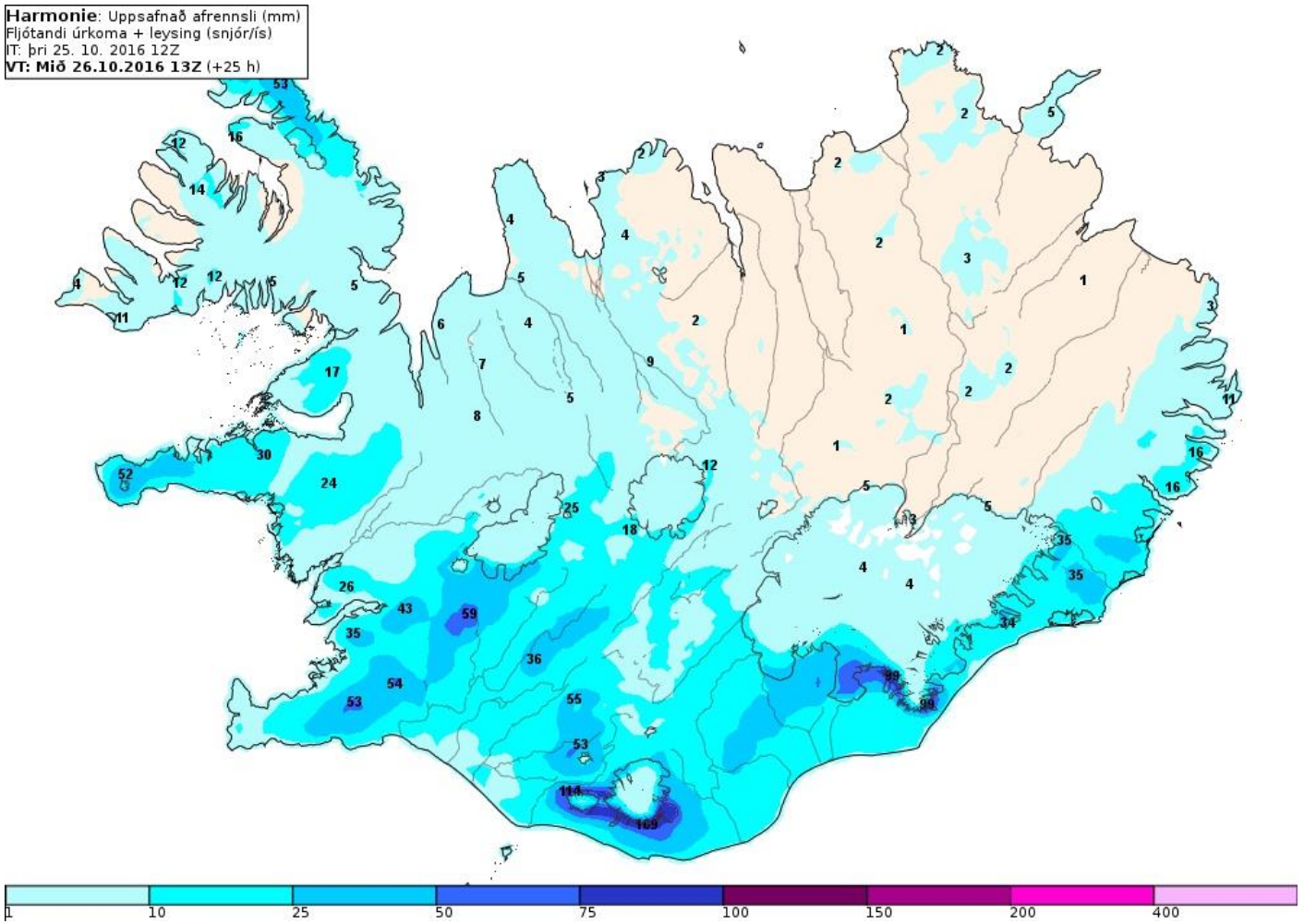
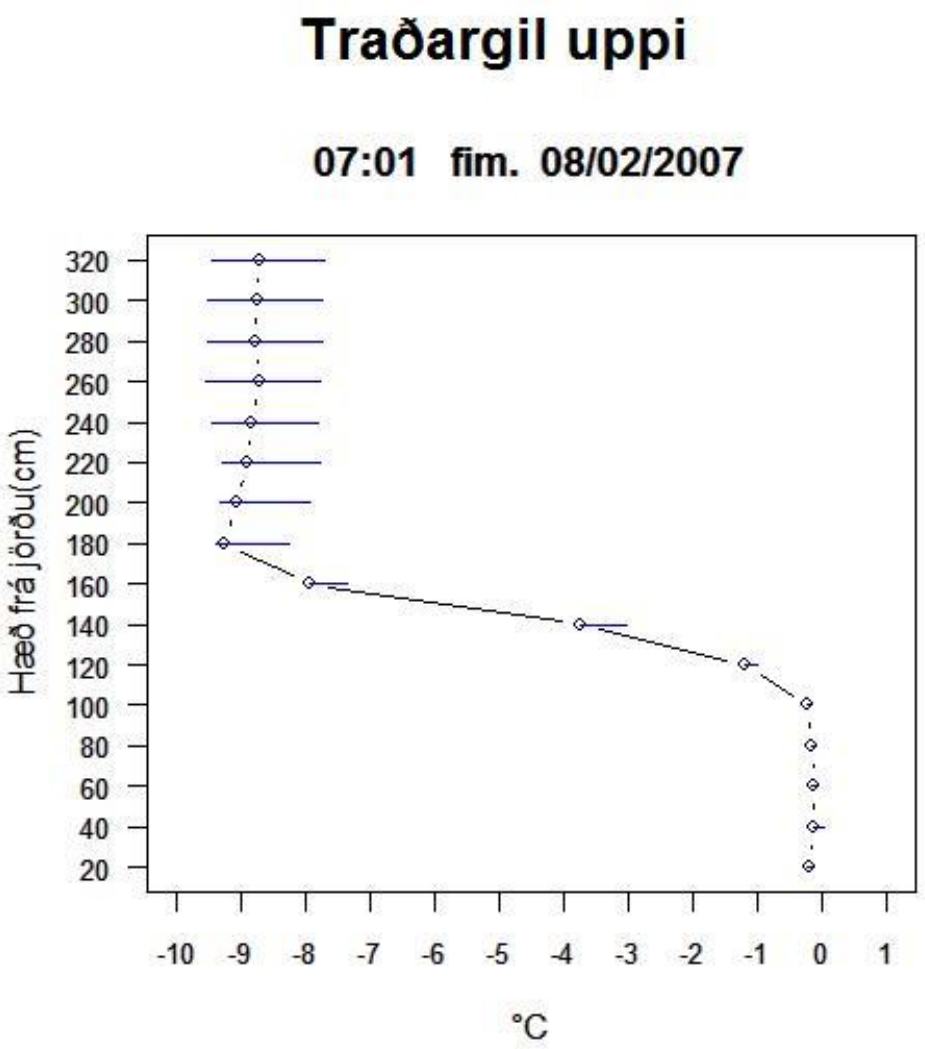


Sólarhringsúrkoma 25.10.2016 kl. 9

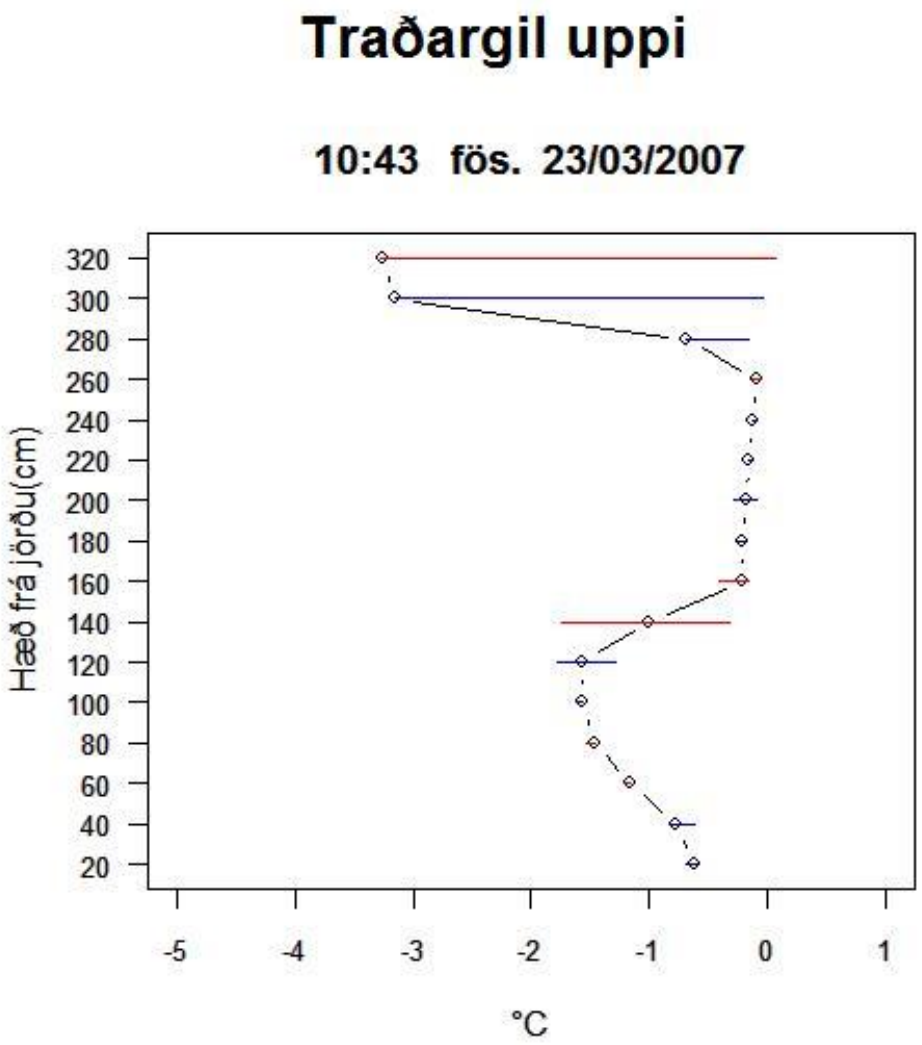
Runoff map


Harmonie: Uppsafnað afrennsli (mm)
Fljótandi úrkoma + leysing (snjór/ís)
IT: þri 25. 10. 2016 12Z
VT: Mið 26.10.2016 13Z (+25 h)
1
10
25
50
75
100
150
200
400

SM4 sensors
Snow and air temperature up in mountains



SM4 sensors


Traðargil uppi
10:43 fös. 23/03/2007
Hæð frá jörðu(cm)
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
-5
-4
-3
-2
-1
0
1
°C

Threshold levels for precipitation

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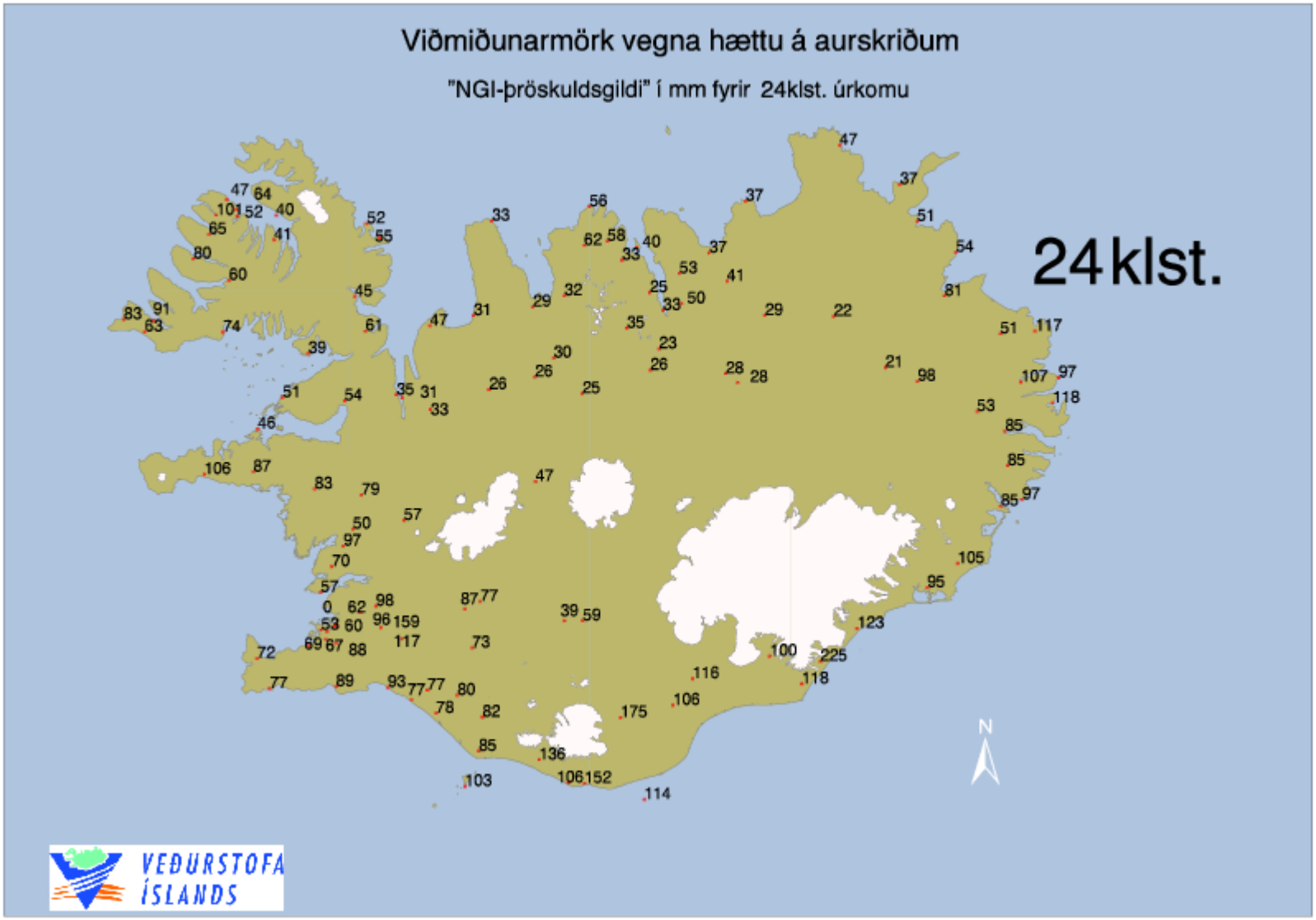
Threshold levels for precipitation

- Based on NGI values (Sanders 1995)
- Proportion of average annual precipitation for each location
  - Big difference between areas
  - Terrain in balance with the local climate

Threshold values for 24 hour rain



Focus areas

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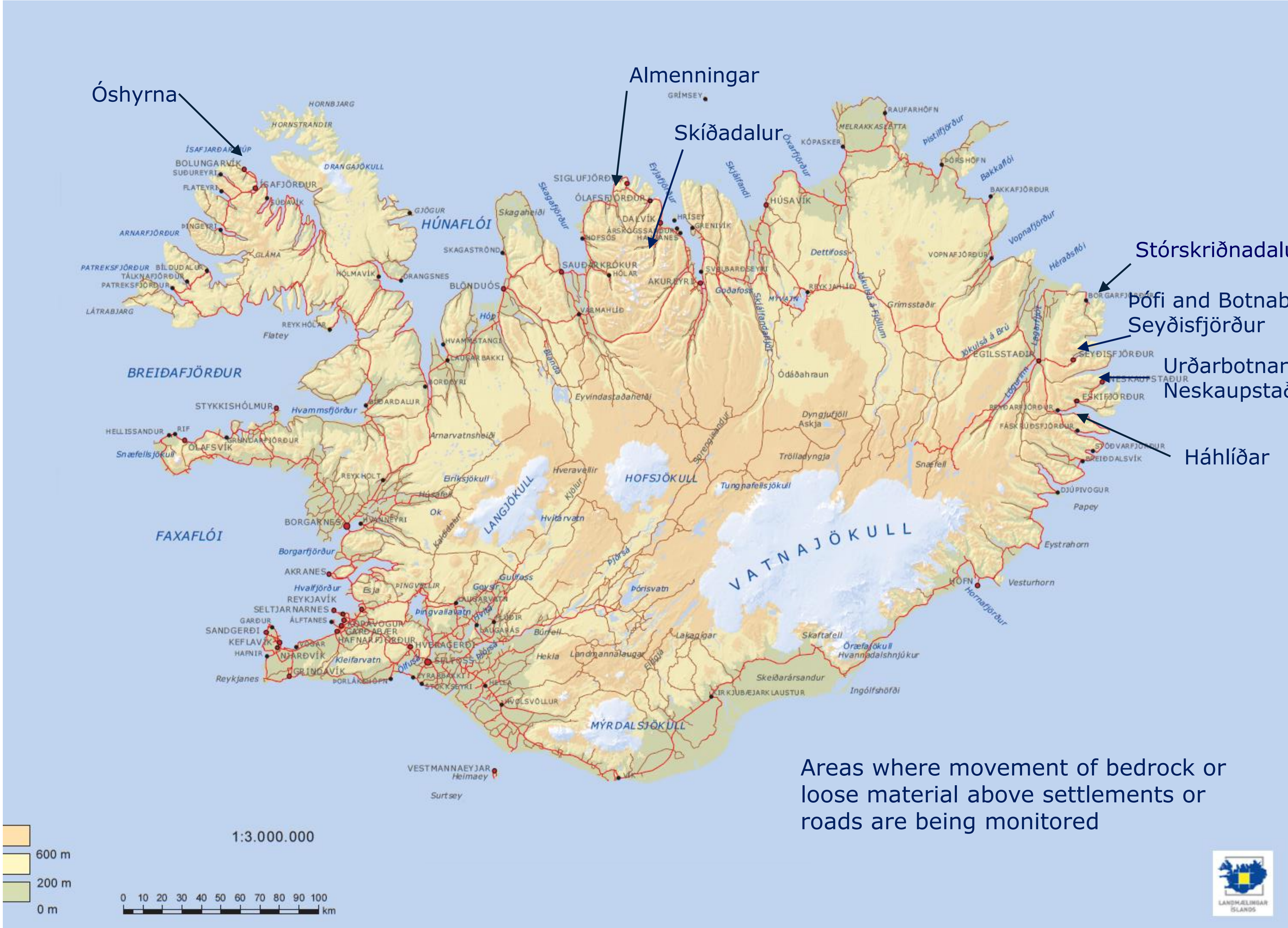
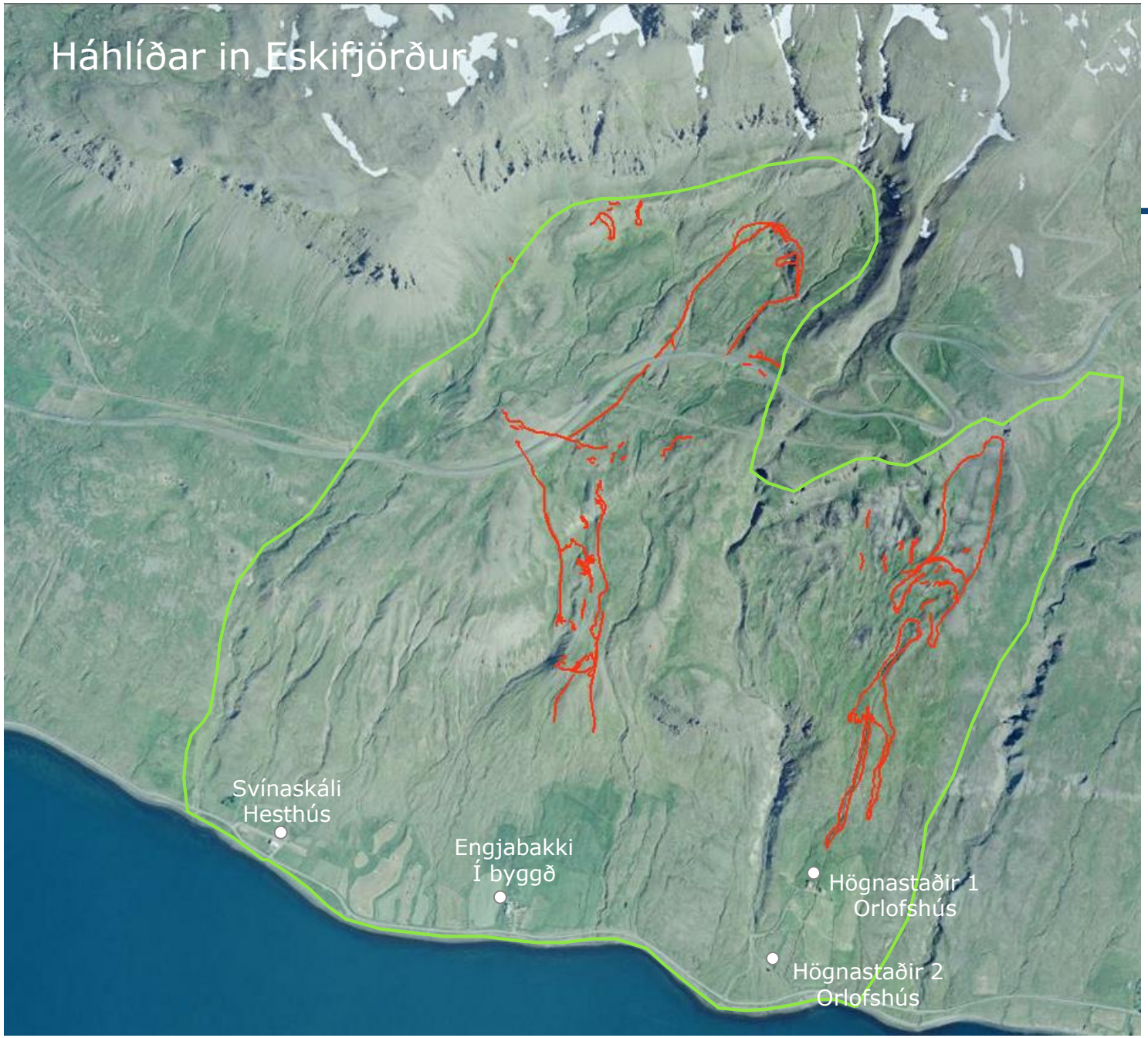
Special attention is given to areas where movement of bedrock or loose material has been spotted

- Observation by snow observer or other local contact persons
- Manual measurement of movement
- Fixed points for accurate GPS measurements
- Satellite data for detection of areas where movements are occurring (inSAR)
- Identification of areas with permafrost
  - Terrain characteristics
  - Ground penetrating radar?



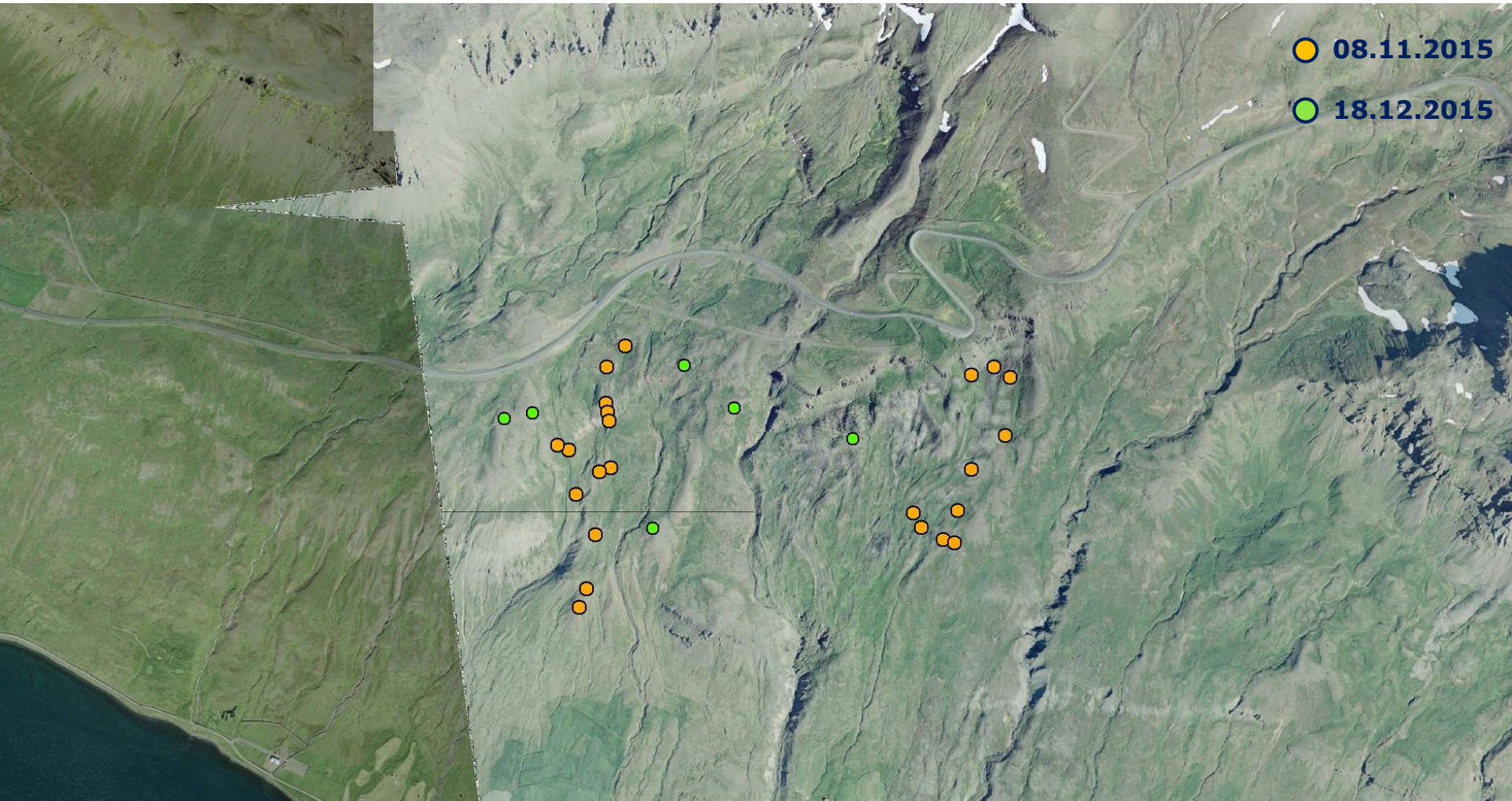
Areas where movement of bedrock or loose material above settlements or roads are being monitored

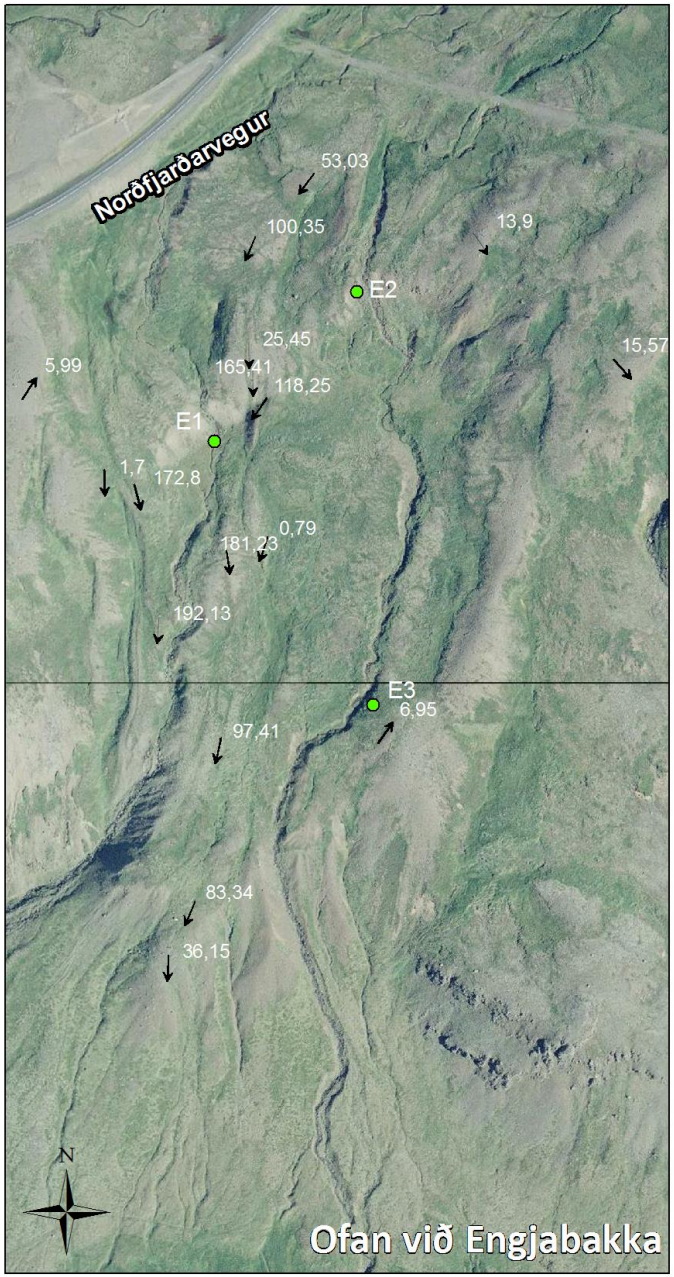


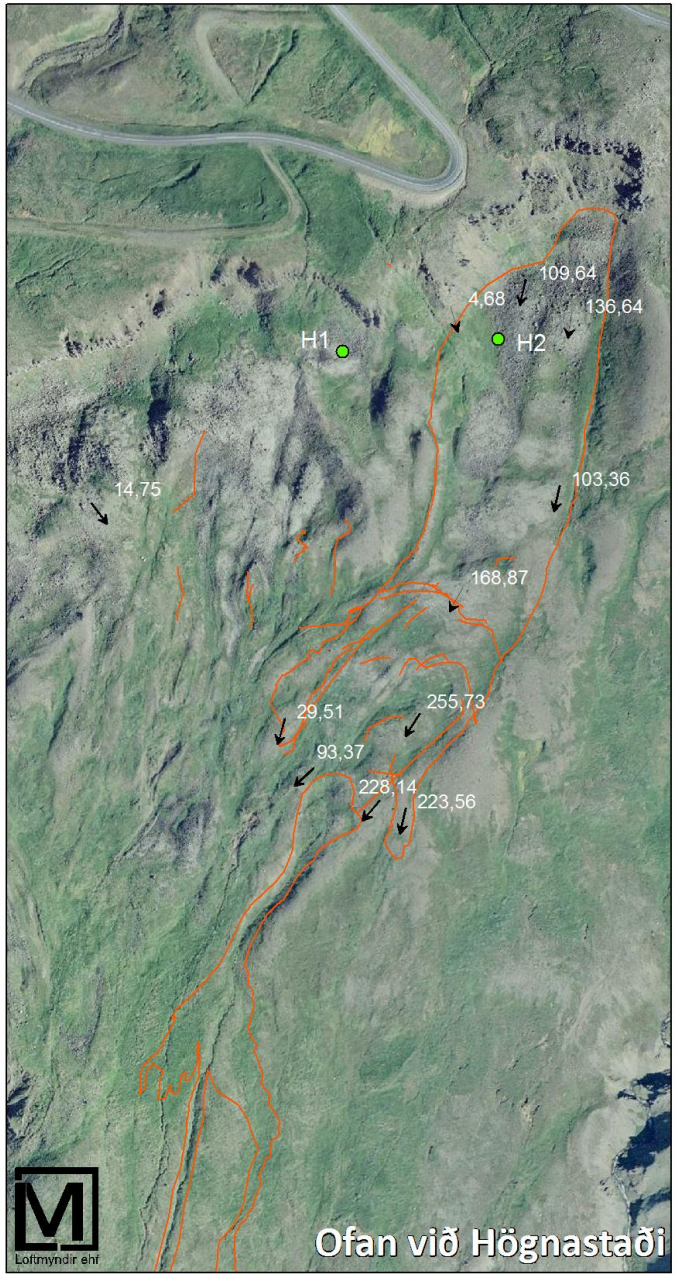
Veðurstofa Íslands

Location of fixed GPS points within the area

Veðurstofa Íslands







Veðurstofa Íslands

Eskifjörður

Hreyfingar í lausum jarðlögum

Tímabil: 08.11.16 - 08.07.16

Skýringar

Sprungur mældar með GPS

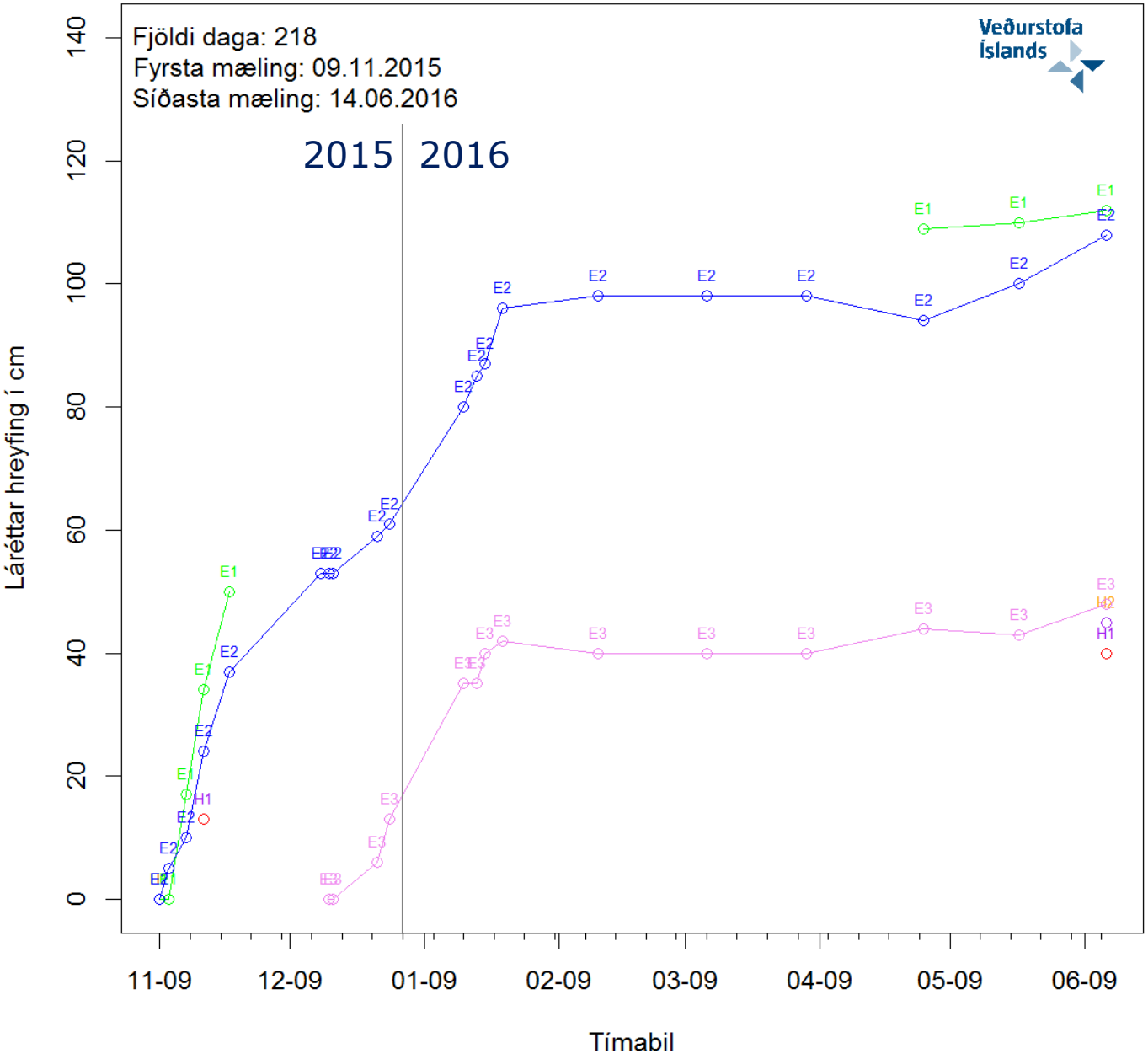
HST-1 GPS mælistaðir (fastpunktar)

H1 Stikumælistaðir

0 100 200 300 400

Kvarði: 1:4.000

Hreyfingar í hlíðinni ofan við Högnastaði(H) og Engjabakka(E)



Veðurstofa Íslands


E
H

Thank you !

7. Júlí 2016