

Short introduction to IMO & Ocean models, storm surge modeling, risk assessment etc.

Halldór Björnsson
Angel Ruiz-Angulo



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OUR ROLE

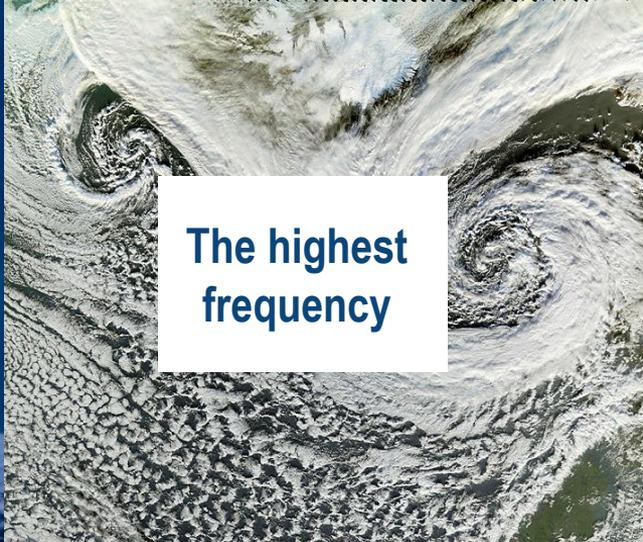
The Icelandic Meteorological Office contributes to improved security for the public, property and infrastructure against the forces of nature, while supporting the sustainability of natural resources and maintaining social efficiency




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**The greatest
asset damage**



**The highest
frequency**



**The greatest
loss of life**



**Great
property damage**



**High
frequency**



**Considerable
damage**

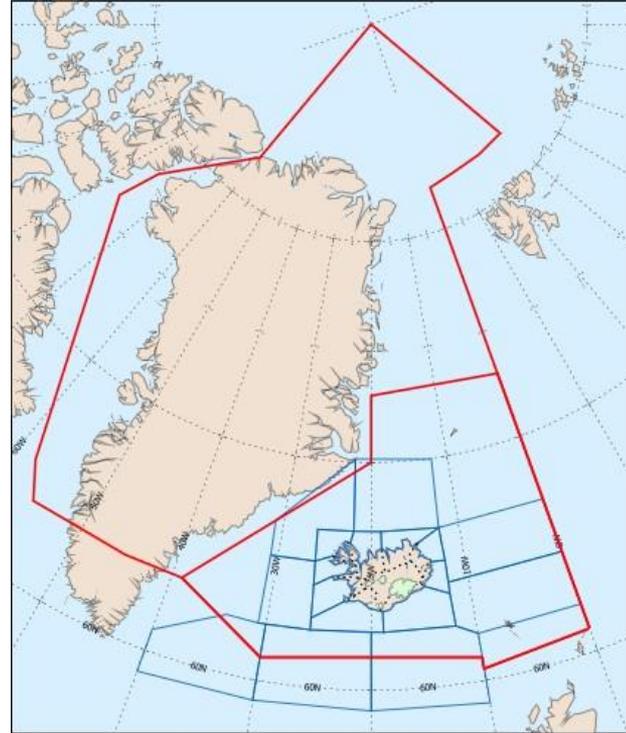
An Extensive Service Area

IMO monitors and issues forecasts for

- ▶ Land and sea. In total 1,460 thousand km²
- ▶ (Iceland is ~103 thousand km²)
- ▶ Large airspace as a service to the Joint Finance Agreement of International Civil Aviation Organization (ICAO). ~15% increase in flight traffic per year during the last 5 years (3.5% globally)

IMO is a “State Volcano Observatory” nominated by the Icelandic Transport Authority and The International Civil Aviation Organization (ICAO)

- ▶ Monitoring volcanic eruptions and ash in the atmosphere



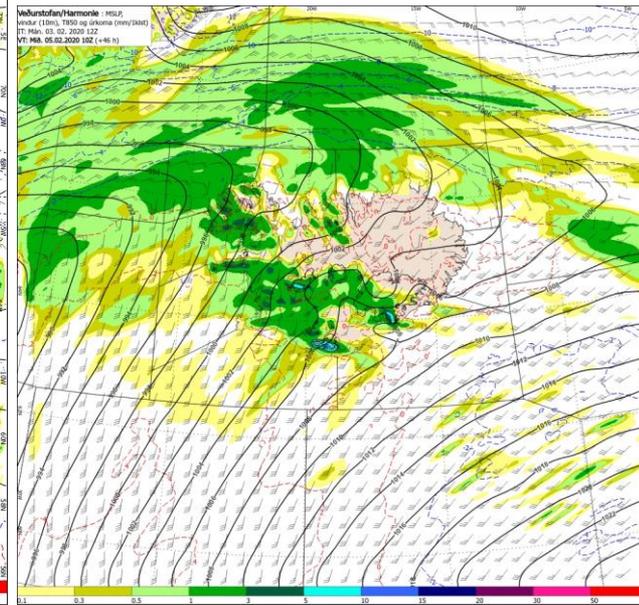
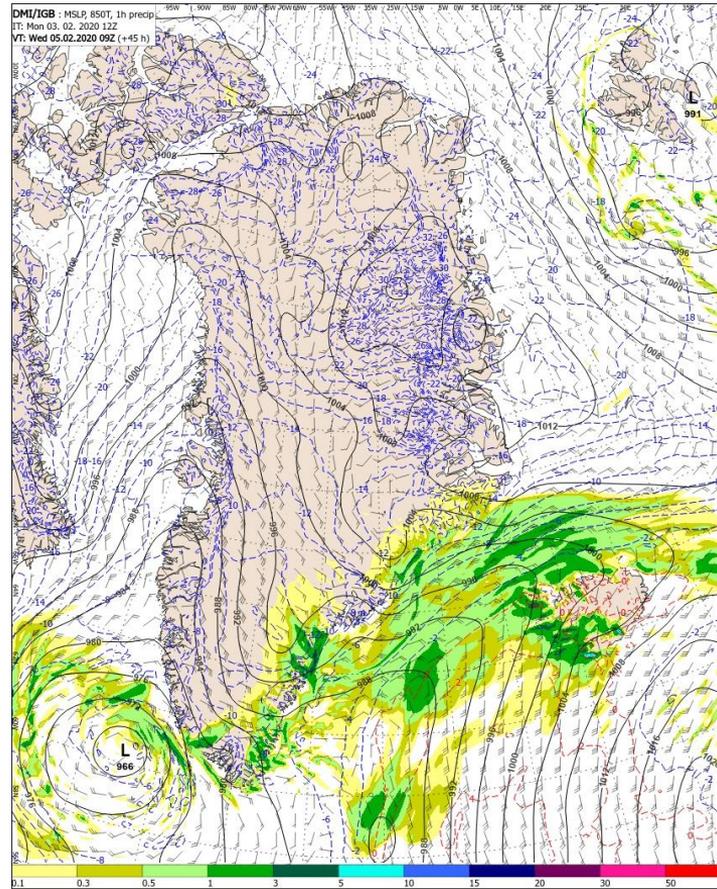
Weather prediction models for a large area

In collaboration with DMI

- ▶ Weather forecast for Greenland and Iceland
- ▶ 66 hour forecast/4x daily
- ▶ Run on DMI computers based in Iceland

A local forecast at ECMWF

- ▶ Weather forecast for Iceland calculated
- ▶ 66h forecast/4x daily
- ▶ High resolution forecast (750m) for a smaller domain
- ▶ 18h forecast/4x daily
- ▶ Both run on ECMWF computers in Reading, UK



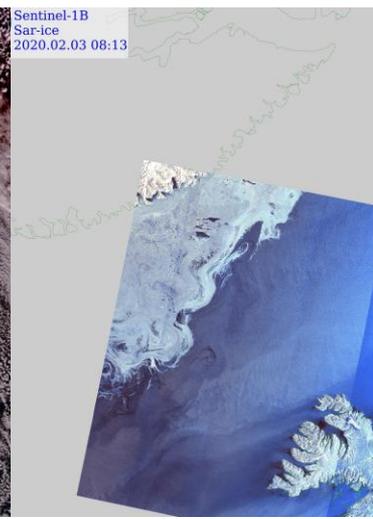
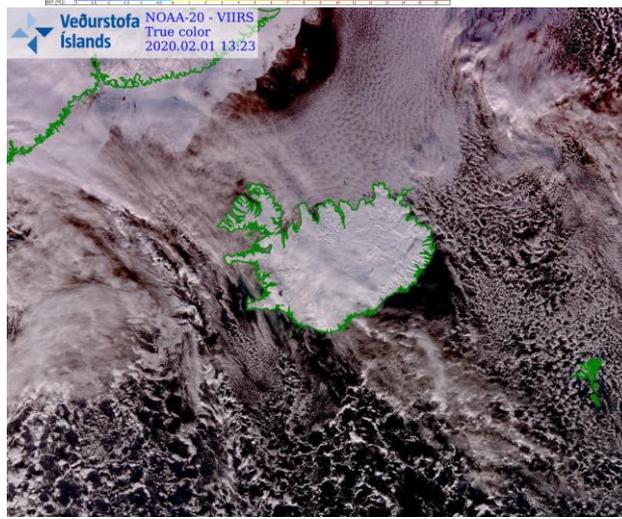
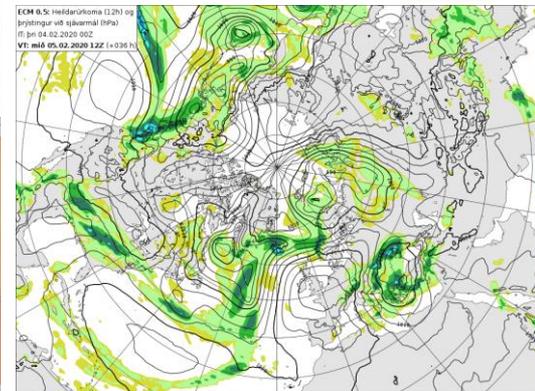
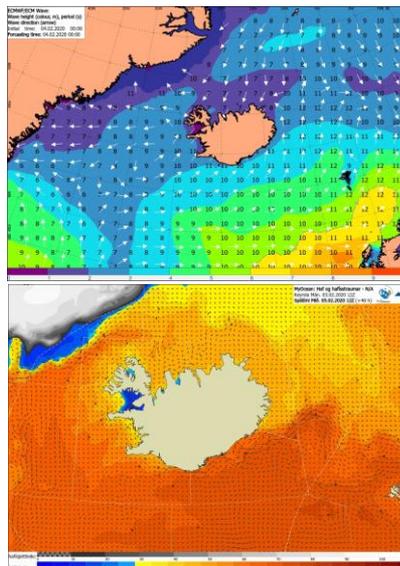
Models and remote sensing data

International collaborators

- ▶ European Center for Medium Range Weather Forecasting (ECMWF)
 - ▶ Global forecast model for weather and waves
- ▶ Copernicus Marine Service (MyOcean)
 - ▶ Ocean & Sea Ice forecast

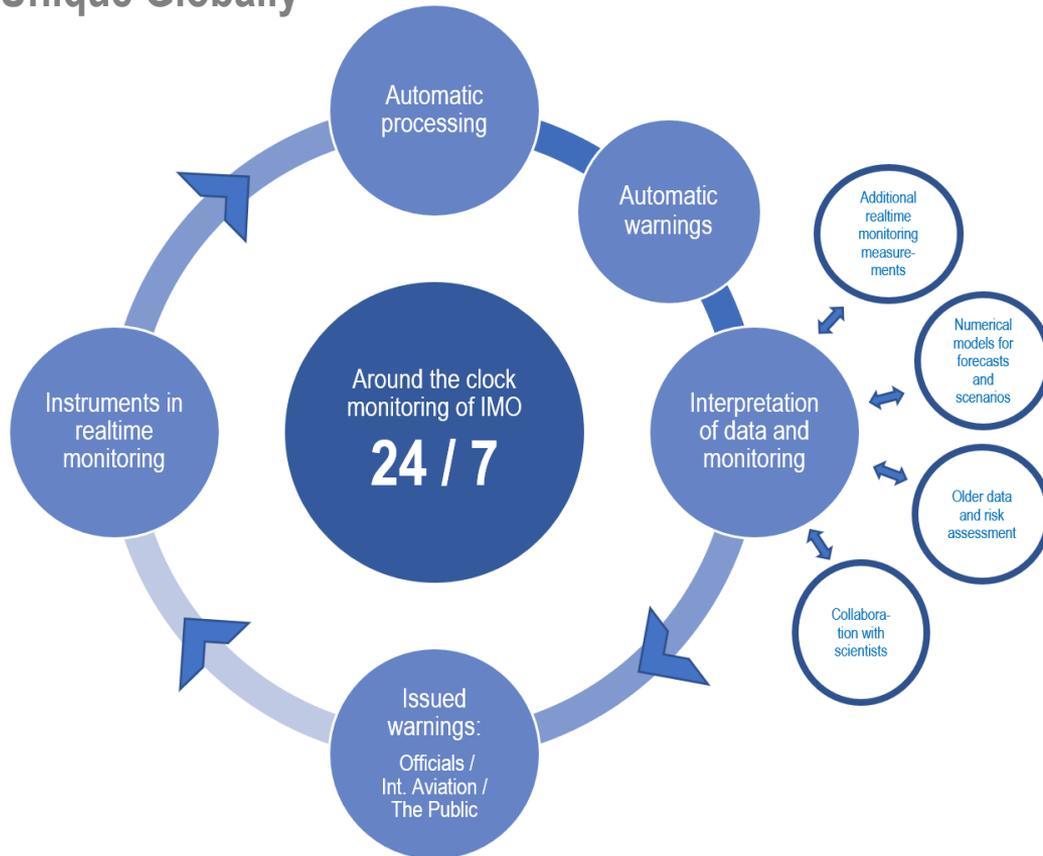
Remote sensing data

- ▶ Eumetsat/ESA
 - ▶ Near real time acquisition from Polar and Geostationary satellites
 - ▶ Thermal and visible imagery as well as SAR
 - ▶ Processed products such as ASCAT Waves, NWCSAF and OSISAF (cloud parameters, sea ice etc).
- ▶ NOAA/NASA
 - ▶ Thermal and visible images (Modis/NOAA)



Integrated Monitoring

Unique Globally



24 / 7 Monitoring

An Extensive Monitoring Network

Earth

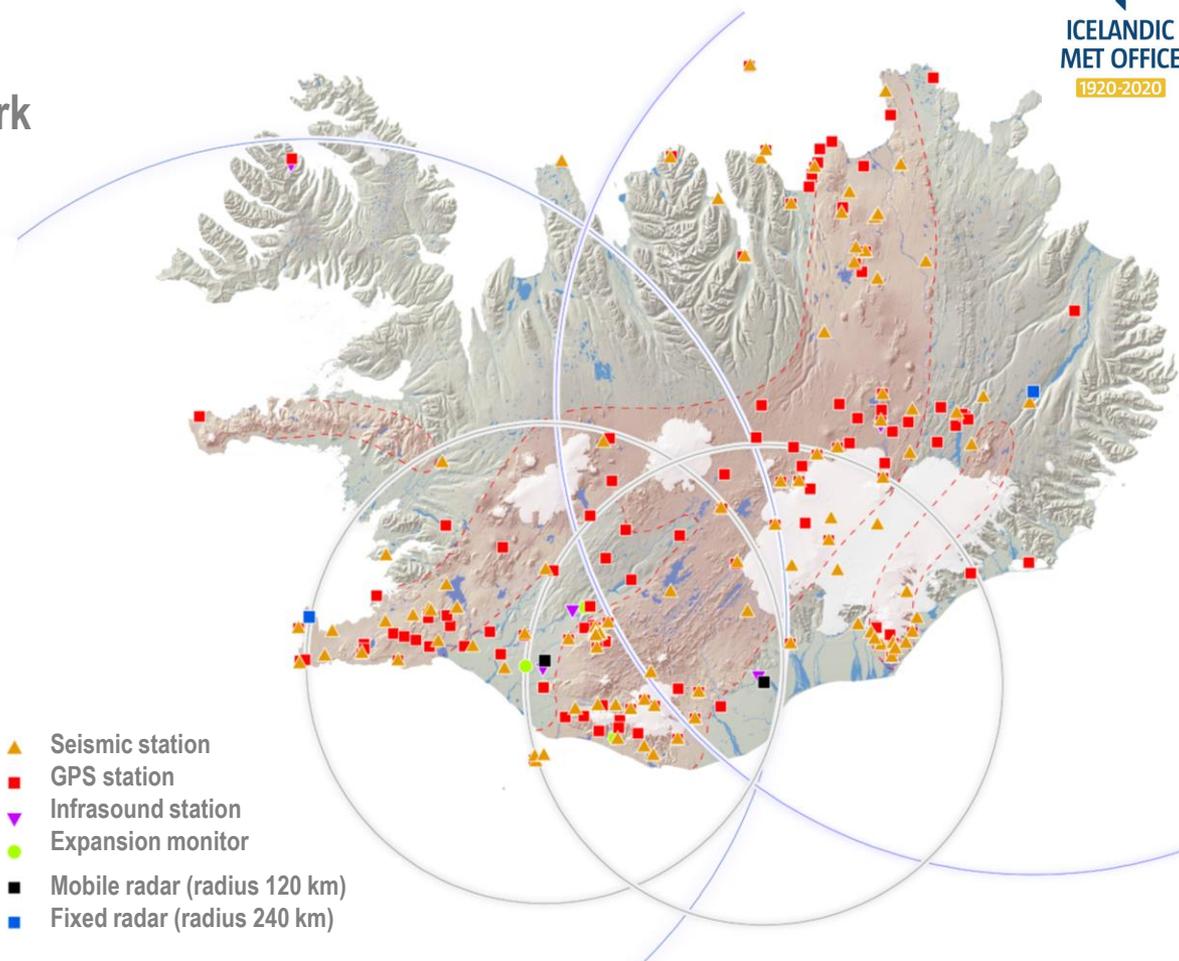
- ▶ Seismic stations
- ▶ GPS monitoring system
- ▶ Expansion measurement system

Atmosphere

- ▶ Weather stations
- ▶ Gas measurements
- ▶ Radars

Hydrology

- ▶ Water height monitoring system
- ▶ Conductivity monitoring system
- ▶ Snow depth sensor

- 
- ▲ Seismic station
 - GPS station
 - ▼ Infrasound station
 - Expansion monitor
 - Mobile radar (radius 120 km)
 - Fixed radar (radius 240 km)

24 / 7 Monitoring

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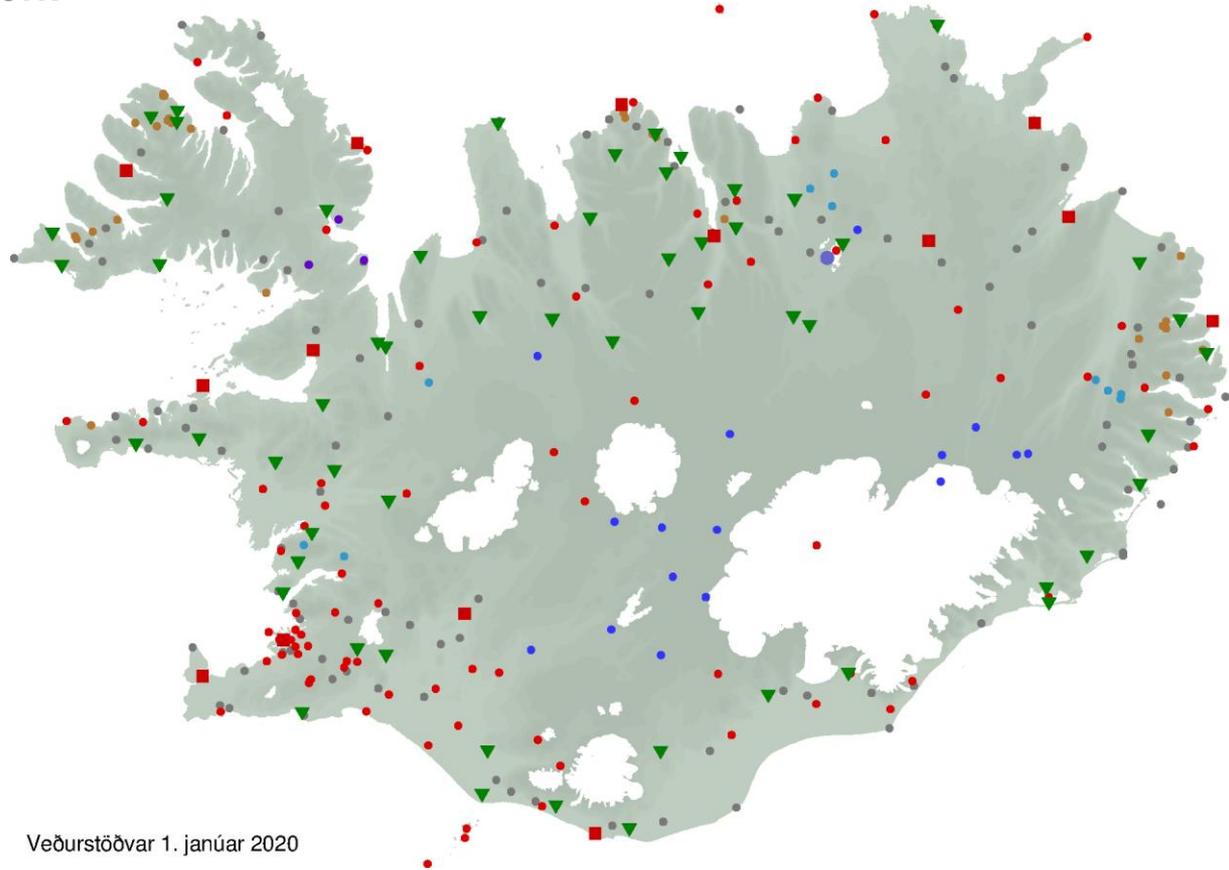
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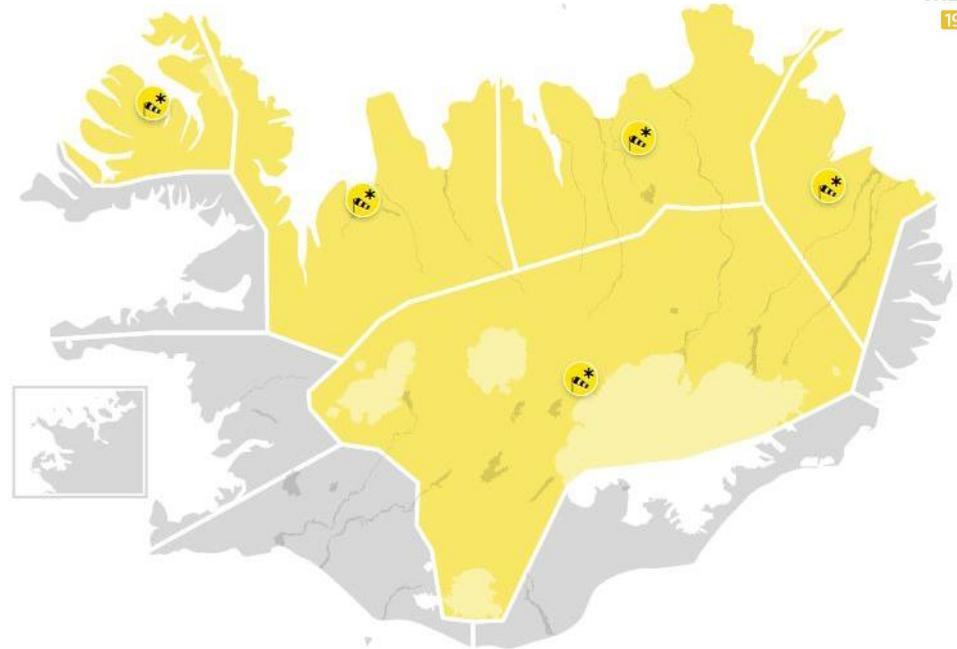
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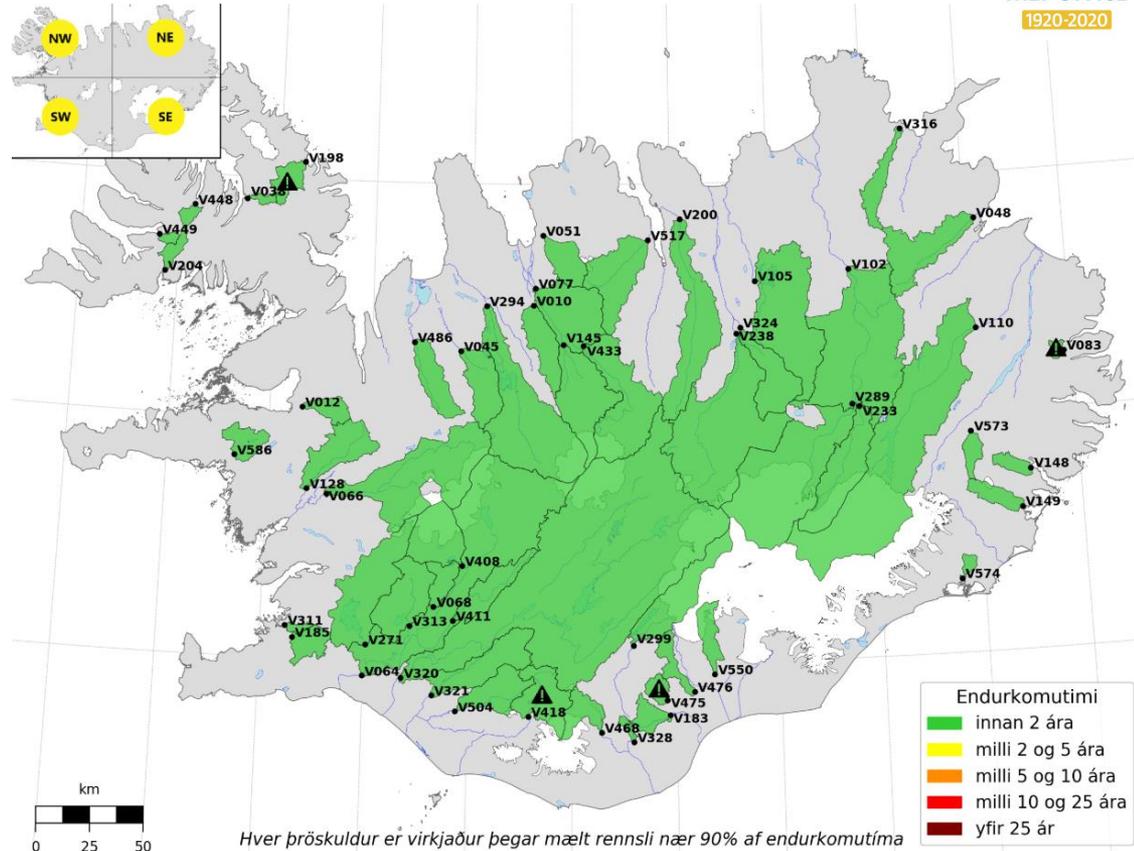
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New Challenges

Dissemination of Our Services

Increased vulnerabilities

- ▶ Merger of local communities, new master plans and land usages
- ▶ Increased number of tourists, where to and how they travel

Unrest behavior of dangerous volcanoes

- ▶ Bárðarbunga
- ▶ Öræfajökull

Climate change

- ▶ Water floods due to increased rain intensity
- ▶ Increased danger in coastal areas due to raised sea level and storminess
- ▶ Avalanches due to glacier retrieval and declining permafrost



Ocean modelling challenges

Regional ice and ocean model

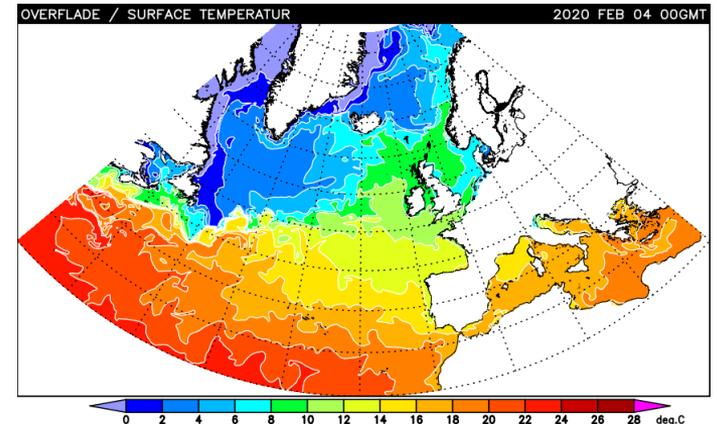
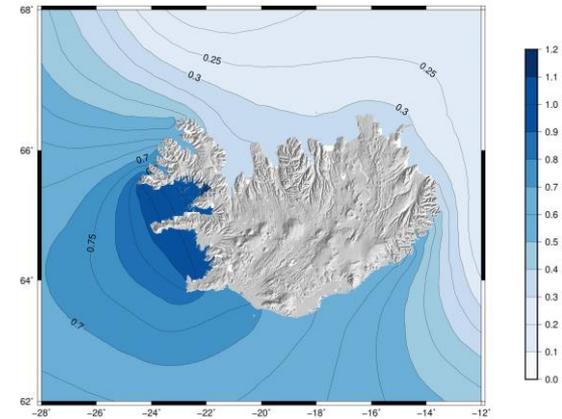
- ▶ DMI runs a regional ocean model for this region.
 - ▶ SST, SSH (Tides), currents etc.
 - ▶ Logical starting point for a modelling chain (same atmospheric model etc)

Storm surge model

- ▶ Are working on adapting the DelftFM model for Icelandic conditions to predict storm surges
- ▶ Needs to correctly handle tides, air pressure and winds
 - ▶ Complications when it comes to waves (scope for collaboration?)

Risk assessment

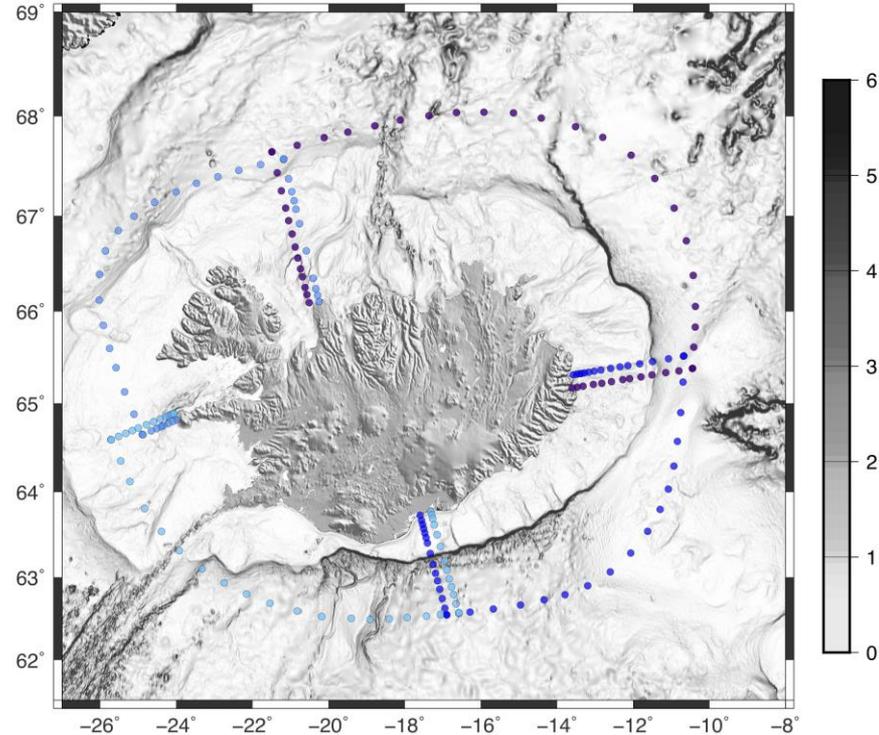
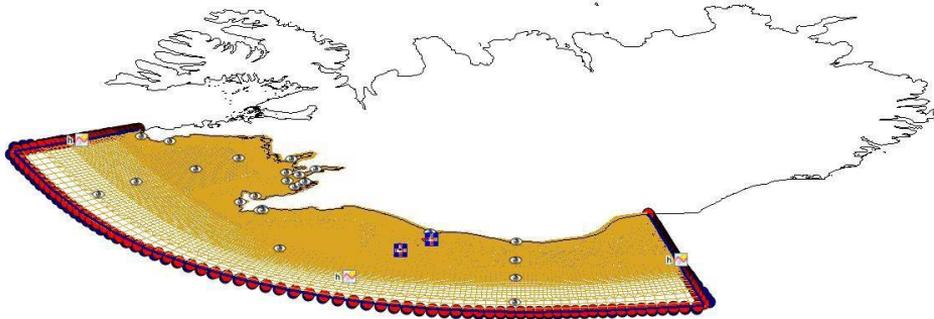
- ▶ Surge model will be used to estimate flooding risk in different regions and for different scenarios for sea level rise



Coastal flooding: storm surge

Storm surge model specifications (so far)

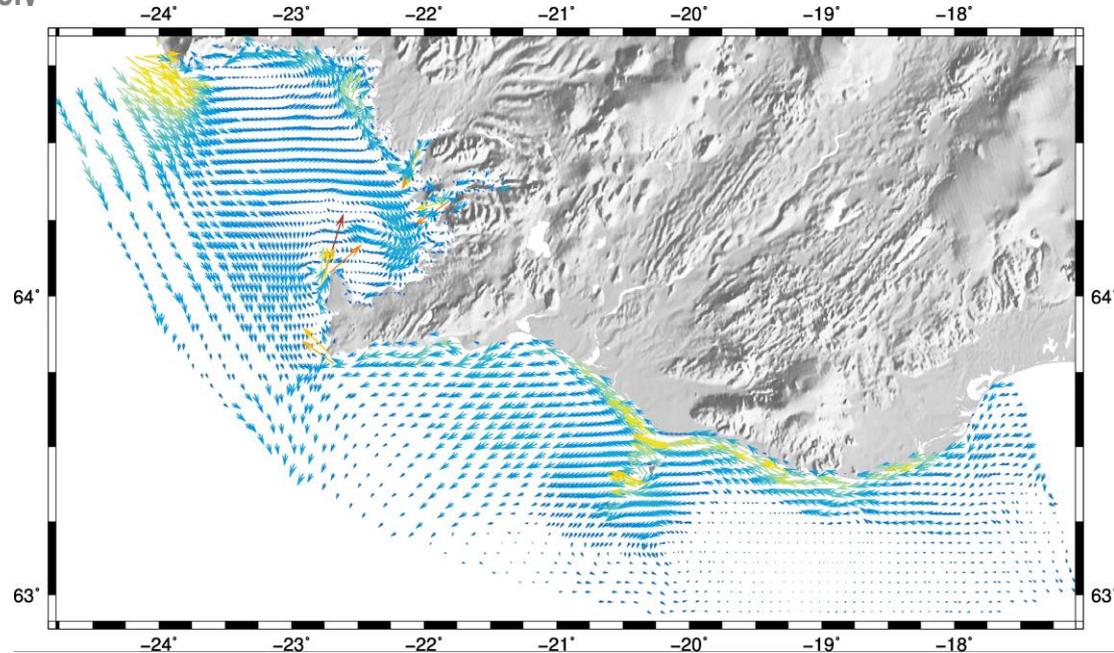
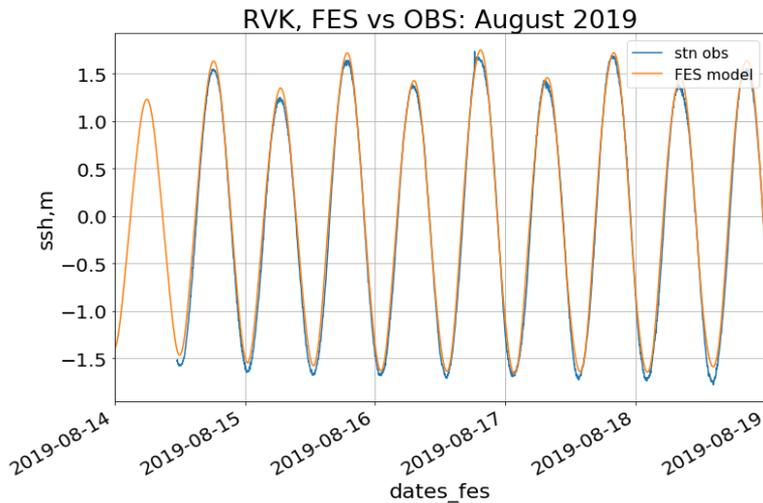
- ▶ Computational domain divided in 4 sectors
- ▶ Flexible mesh: triangular 500 m resolution at the coastline and 10x5km at the boundaries
- ▶ Open boundaries forced with tidal constituents from FES2014
- ▶ Stability tests: SW domain: tide only, tide+uniform wind, tide+pressure, and tide + wind + pressure



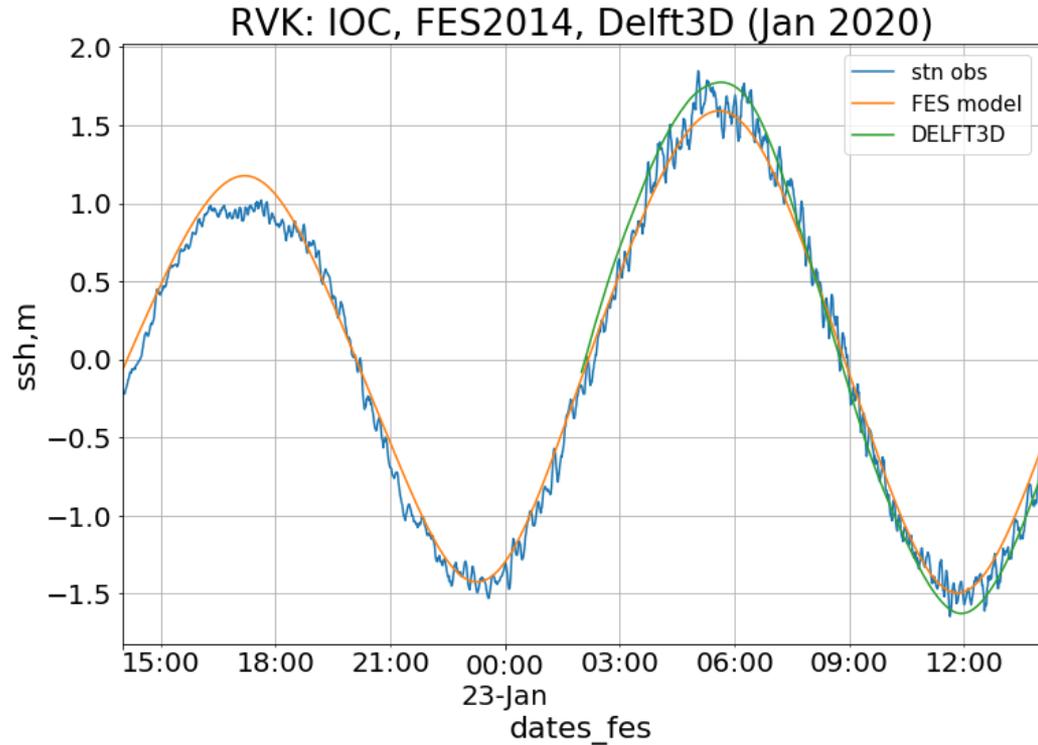
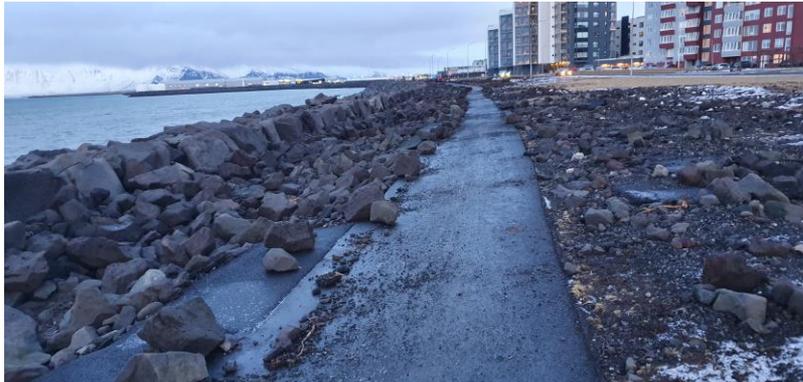
Coastal flooding: storm surge

SW domain validation

- ▶ The numerical model propagates tides relatively well, RVK tide gauge validation
- ▶ Tidal currents capture the main features



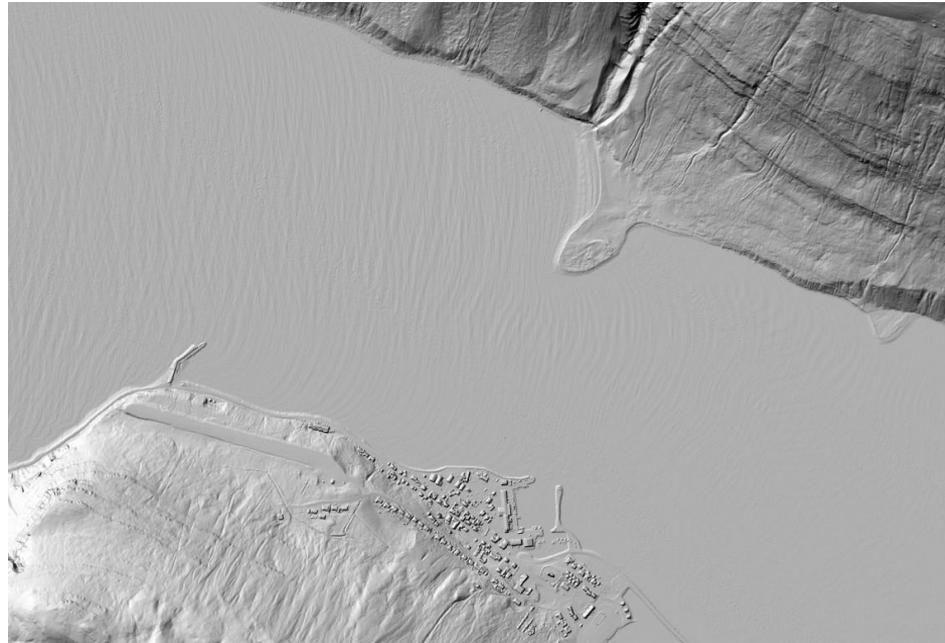
Coastal flooding: storm surge + waves



Coastal flooding: avalanche induced tsunami

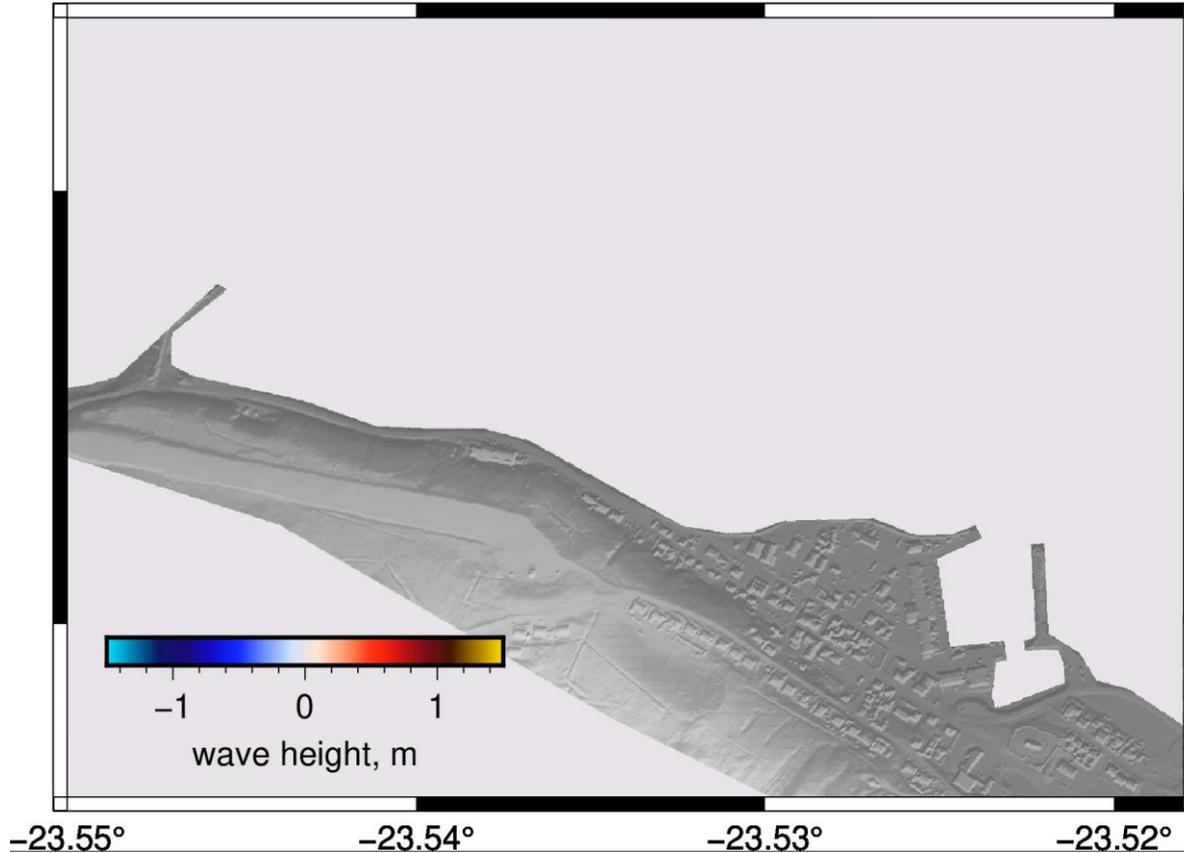
Tsunami modeling and fjords challenges

- ▶ Numerical model: GeoCLAW (Leveque et al., 2011)
- ▶ Topography: Arctic DEM 1x1 m
- ▶ Bathymetry: Nautical charts and all surveys available
- ▶ Challenge: merging them and zero reference them
- ▶ Recent example: Suðureyri, 14.01.2020

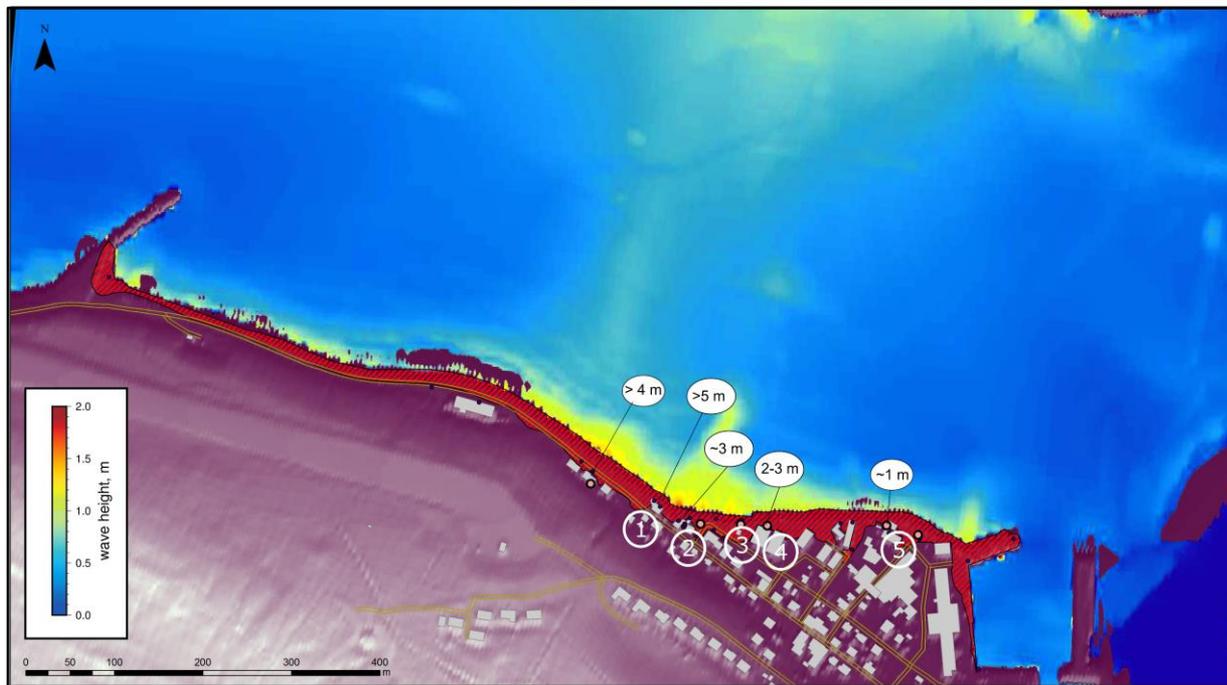


Coastal flooding: avalanche induced tsunami

Elapsed time: 0 seconds



Coastal flooding: avalanche induced tsunami



Suðureyri - 14.01.2020 23:05
Tsunami caused by an avalanche
Maximum wave height - modelled

-  Houses
-  Roads
-  Area affected by the wave
-  Height of the splash from the wave

Tsunami modelling: Angel Ruiz-Angulo
Mapping: Jón Kr, Harpa, Sigríður and Jón Ottó



1
Photo: Jón Kristinn Helgason
A wave crashed on the top of the house and also went over the house



2
Photo: Jón Kristinn Helgason
A wave crashed on the windows on the upper floor



3
Photo: Einar Ómarsson
Eye witness pictured the wave coming in at 23:06



5
Photo: Jón Kristinn Helgason
The wave pushed the car on top of another



4
Photo: Jón Kristinn Helgason
The wave damaged the gable of the house

A wide landscape view of a volcanic field. In the foreground, there are large, dark, jagged volcanic rocks. A river flows through the middle ground, winding between the rocks and a sandy beach. In the background, there are low mountains under a blue sky with scattered white clouds.

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