KEEPING TRACK OF RETREATING GLACIERS IN ICELAND

In Iceland maps and spatial data around glaciers are being updated with Sentinel-2 data, a novel way to document rapid changes due to climate change.

The challenge

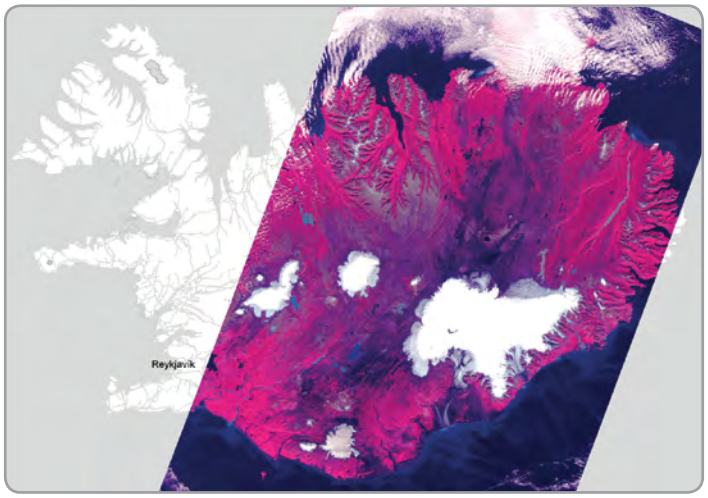
The largest glaciers in Europe are in Iceland and glacial rivers flow from these to sea, crossing the road system in various places. The glaciers are generally retreating inland due to climate change and the glacial river pattern in front of the glaciers is therefore changing. The river flow tends to fluctuate from year to year, thus affecting the road system. Also, glacial outbursts are not uncommon due to volcanism beneath glacier ice. Large scale melting of ice under such conditions causes „jökulhlaup", or the sudden release of meltwater that may amount to 50.000 m3/sec, e.g. the Gjálp eruption in 1996. With a population of less than 340,000, and a total land area of 103,000 km2, Iceland is the seventh least densely populated country in the world. This means that traditional and recurrent monitoring of land from airplanes is much too expensive for glaciers in remote areas. Monitoring from space with the Sentinels is therefore a good option due to no cost, high revisit time and large area coverage, which is very important when monitoring the rapidly changing glacial landscape.

The space based solution

The National Land Survey of Iceland is responsible for maintaining a free and open base map database in Iceland. A regular update of data around the glaciers has not been possible due to lack of uniform data and high cost, resulting in outdated information about the glacial river pattern and the glacier extent. The optimal solution to that problem came when the Sentinel-2A satellite crossed Iceland on 30 August 2017 and imaged nearly 2/3 of the country. This timing, i.e. late summer, enabled extraction of exact glacier outlines for almost all of Iceland`s glaciers. Thus, the Late Summer Snow Line (LSSL) is established which is an approximate for the Equilibrium Line as an indicator for the minimum annual glacier extent. Sentinel-1 and Sentinel-2 dense time series can also be used to estimate the glaciers' velocities. This image has since been used to extract the glacial river pattern in front of glaciers as well as the glacier extent. Manually, the results are cleaned by visual comparison of ground truth as seen in the Sentinel imagery.

Benefits to Citizens

Using Sentinel imagery to update the datasets around the glaciers of Iceland has many benefits. The first and most obvious is to monitor glacier retreat resulting from climate change. Also important is how this work aids the monitoring of hazardous proglacial environment, where glacial river flow paths need to be upgraded frequently to update maps and map services. This updated data makes travelling around the glaciers safer, especially for tourists with little knowledge of the glacier environment. It can also be mentioned that about 87% of the energy used in Iceland is from renewable sources of which 80% is from hydropower, largely from glacial rivers. Monitoring the glacier environment is therefore important to secure the future of these power plants. The cost related to updating this data with Sentinel imagery is marginal



Cloud-free Sentinel image obtained August 30th, 2017 roughly covers 2/3 of Iceland.
Credit: Contains modified Copernicus Sentinel data [2017]

Thematic Area: CLIMATE, WATER AND ENERGY

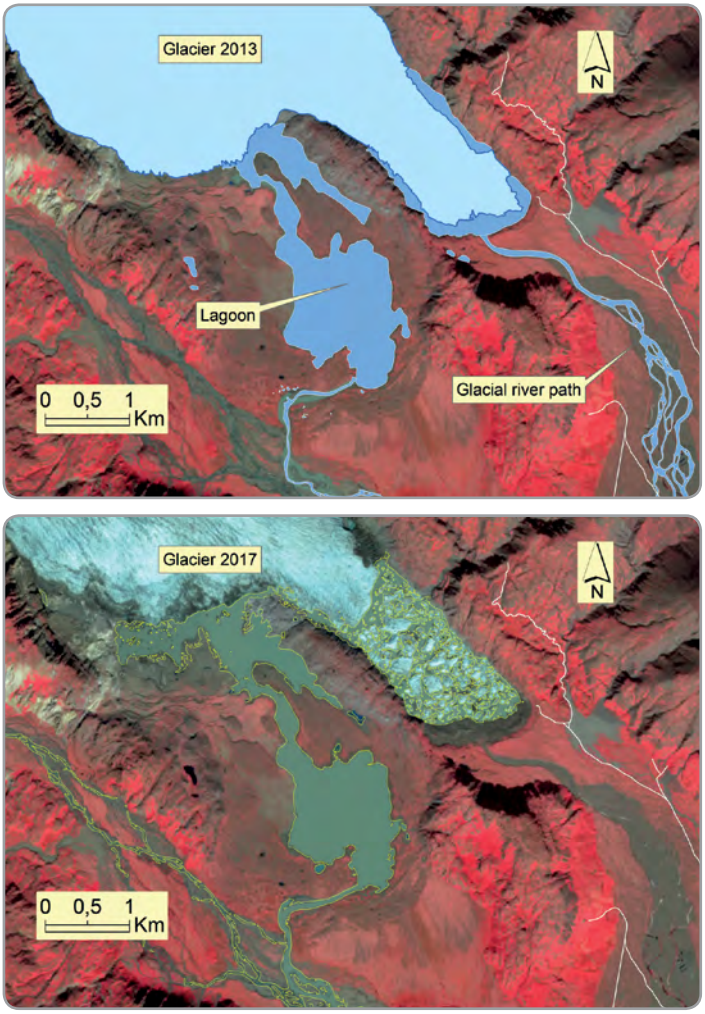
Region of Application: LANDSBYGGÐ

Sentinel mission used: S2

Copernicus Service used: –

Usage Maturity Level: 5

in comparison to aerial, or very high-resolution satellite imagery. Compared with aerial photography the use of Sentinel imagery has the benefit of large simultaneous area coverage. For these reasons Sentinel imagery was used by the National Land Survey as the basis for feature extraction of glacial rivers and glacier extent.



Hoffellsjökull glacier extent and river pattern in 2013 (above) and in 2017 (below) showing 1-2 km retreat.
Credit: Contains modified Copernicus Sentinel data [2017]

> "Using the Sentinel images to update our map database has not only improved our data but also our productivity."

Magnús Guðmundsson,
General Director NLSI

Outlook to the future

The Sentinel-2 large image size and frequent revisit time, will provide the basis for monitoring future changes in glacier extent and glacial river pattern detection in Iceland. It will be possible to monitor these changes more frequently and with more precision than before. In Iceland, the largest volcanoes lie underneath the glaciers. Sentinel imagery can also be used to reveal changes in the glacier surface, such as sink depressions caused by geothermal melting of ice, that may indicate potential volcanic activity. Such rapid melting by subglacial volcanism may cause immense transport of volcanic debris/ash that can partially fill up hydro dam reservoir, thus seriously diminishing their annual capacity.

Gunnar H Kristinsson and Jóhann Helgason
National Land Survey of Iceland, Iceland
Email: johann@lmi.is
gunnar@lmi.is

ABOUT COPERNICUS4REGIONS

This Copernicus User Story is extracted from the publication "**The Ever Growing use of Copernicus across Europe's Regions: a selection of 99 user stories by local and regional authorities**", 2018, Edited by NEREUS, the European Space Agency and the European Commission.
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