Remote Sensing of Snow and Ice

& additional tasks related to Natural Hazard

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University of Iceland

Role regarding Remote Sensing and the Copernicus programme

- Teaching: Undergraduate and Graduate programme
- Research: Earth Sciences, Biology and Engineering
- Environmental Change and Natural Hazards
  - *Participation in research and monitoring efforts in collaboration with the Icelandic Meteorological Office, Department of Civil Protection and Emergency Management, The Icelandic Coast Guard and other institutes and universities.*

Focus on the Copernicus constellation

- SENTINEL 1a and 1b — *Radar*
- SENTINEL 2a and 2b — *Multi spectral, high res.*
- SENTINEL 3a and 3b — *Thermal, altimetry, multi-sp.*

Data is provided free of charge in near-real time through data hubs

Sea ice – challenges and requirements

For navigational safety and climate studies, from growlers to hemispheric coverage

- Dark
- Cold
- Clouds
- Remote
- Changing fast
- Many different surface types
- Hazardous to shipping
- Interaction with climate

- Detailed information on:
  - Extent and concentration
  - Thickness and type
  - Drift
- Real-time acquisition and delivery
- High temporal, spatial and spectral information needed
- Bandwidth issues

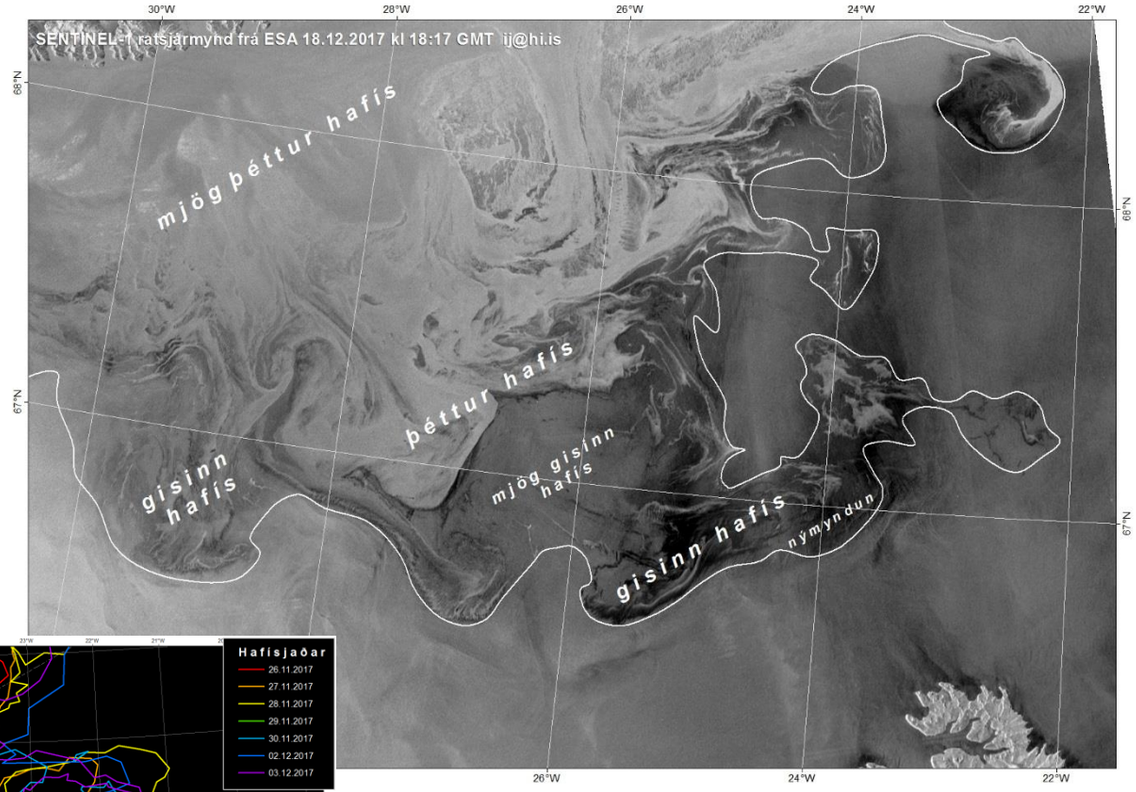
Sea Ice

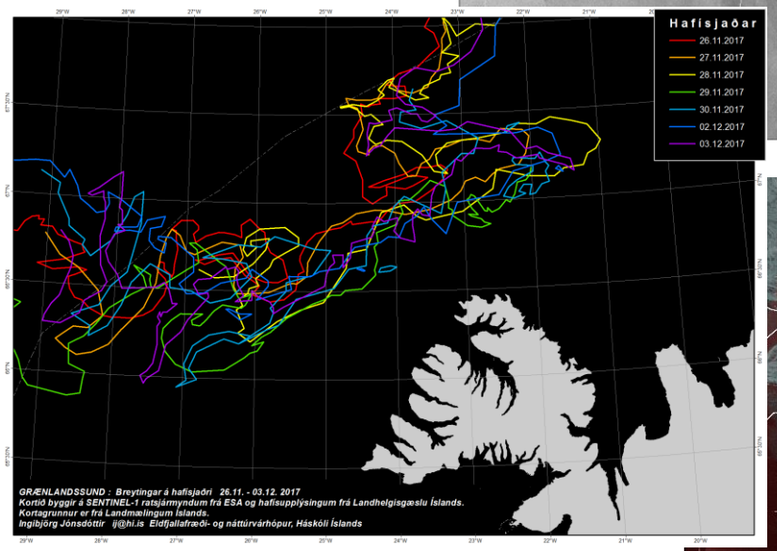
Sea ice information is needed on a daily to hourly basis for navigational safety, when ice is present.

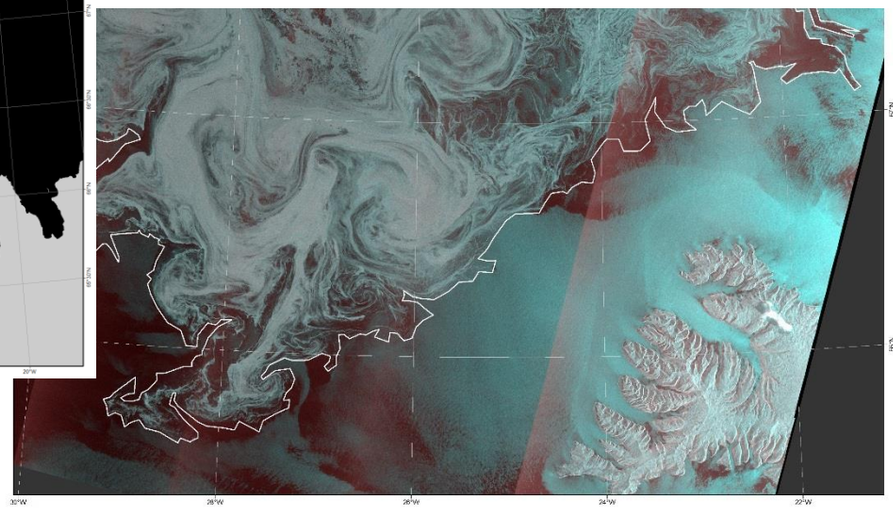
Radar imagery has proven to be very effective for this task, providing data reliably independent of cloud cover or light.

Having such good access to high resolution data so frequently has changed the scene completely for sea-ice monitoring and research

Other imagery and information can be a good support.







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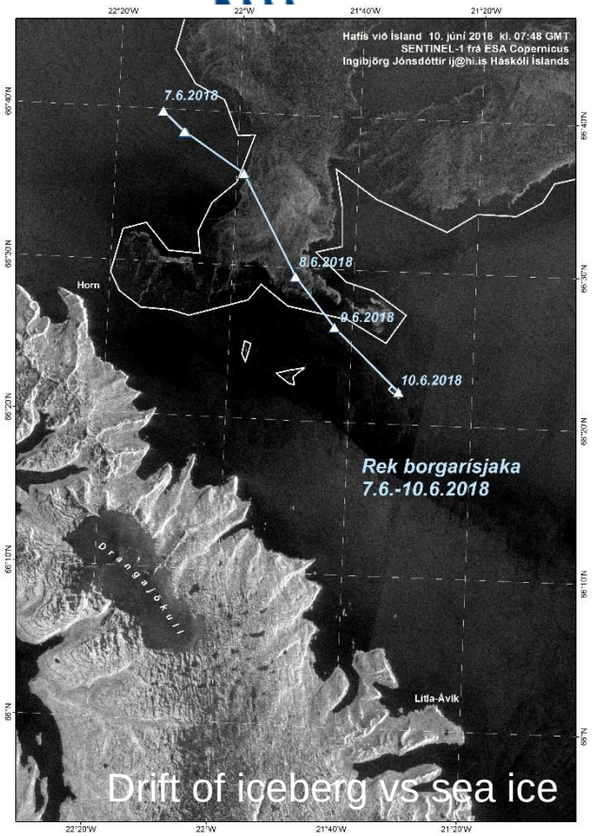
Icebergs

Large icebergs can be detected relatively easily on SENTINEL-1 imagery *(and S-2, clouds permitting)*

With automatic methods or manually

High temporal resolution enables iceberg tracking, deepening our understanding of drift and currents

It can be difficult to differentiate between smaller icebergs and ships, especially outside AIS coverage



Drift of iceberg vs sea ice


Calving event in Jökulsárlón SE Iceland

Several icebergs in Húnaflói

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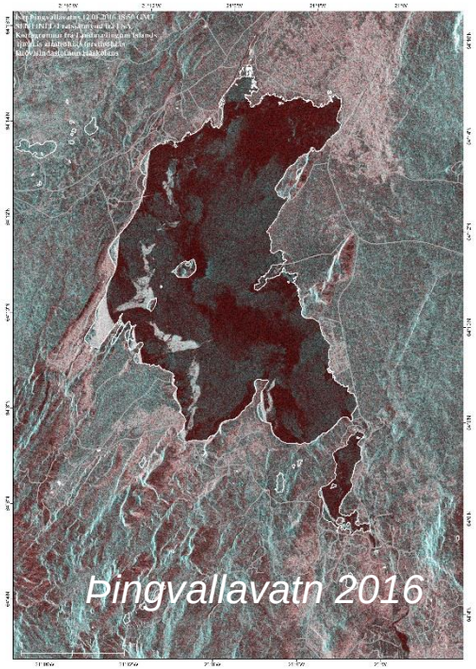
Lake and river ice

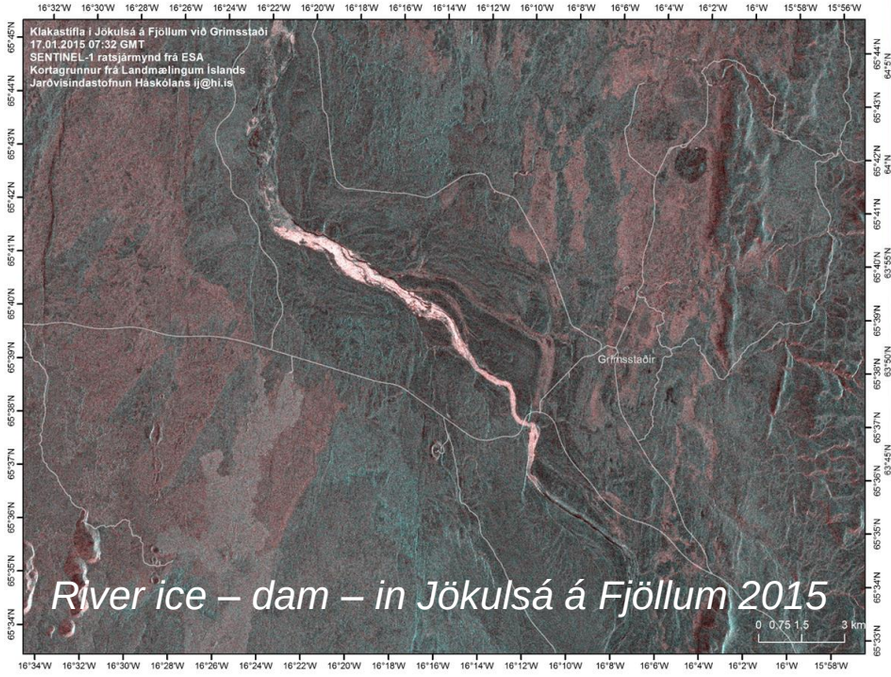
Sentinel-1 is used to detect ice dams in rivers. This can be important for identifying regions that are prone for being affected by such dams, and possible floods.

It has been possible to see the growth and decay from subsequent images.

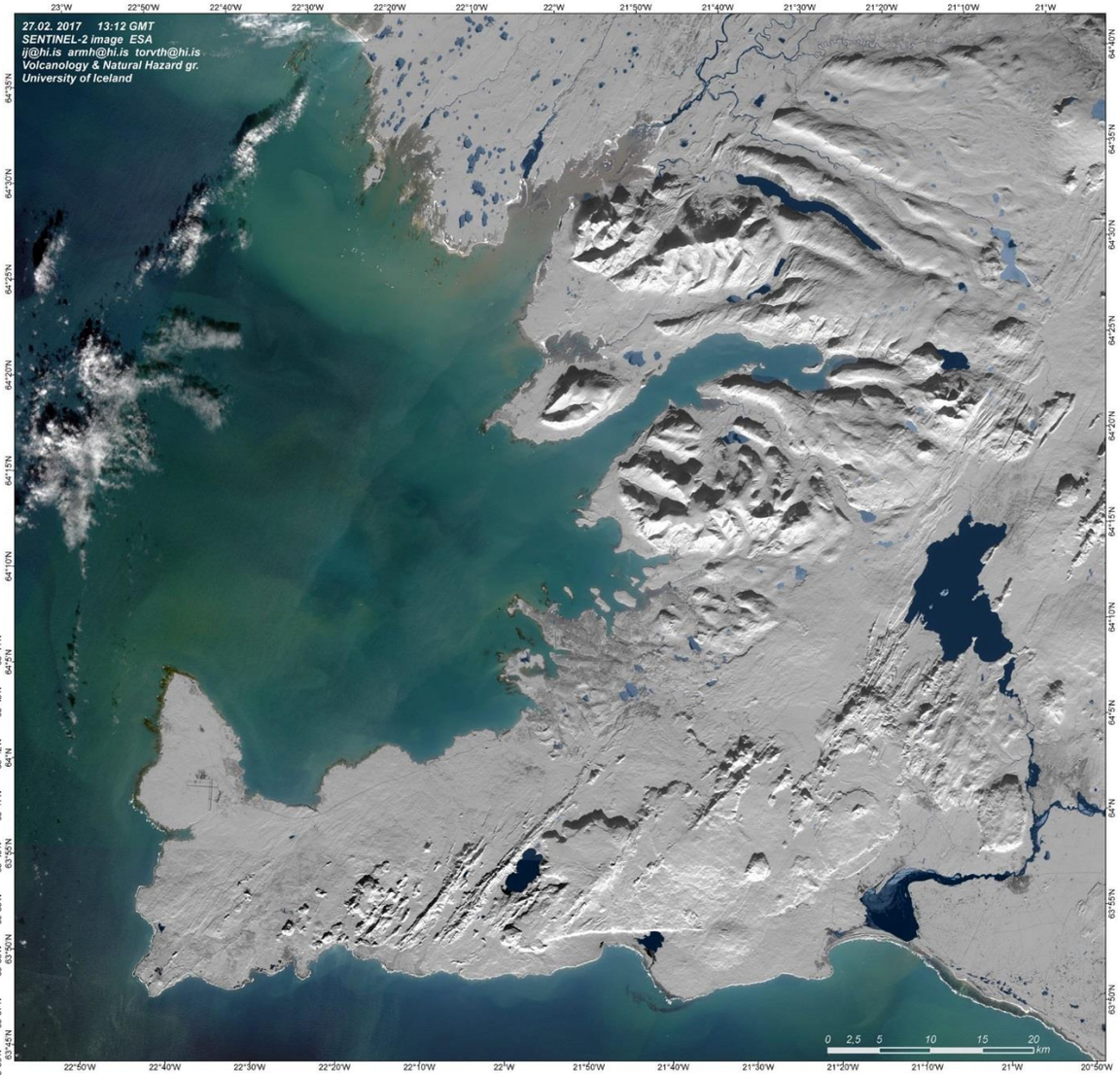
Sentinel 1 and 2 can be used to map lake ice and study structures of the ice: leads and pressure ridges, as well as monitor the formation and melting of the ice



Þingvallavatn 2016



River ice – dam – in Jökulsá á Fjöllum 2015



Frozen and unfrozen lakes and rivers February 2017

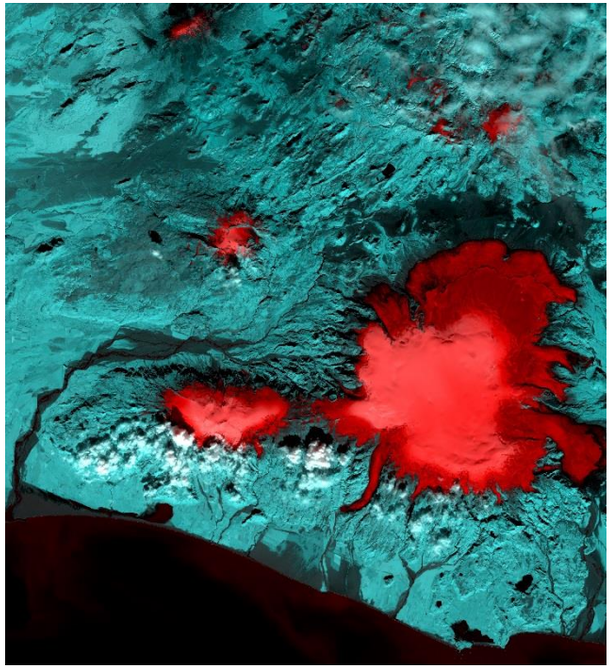
Snow cover

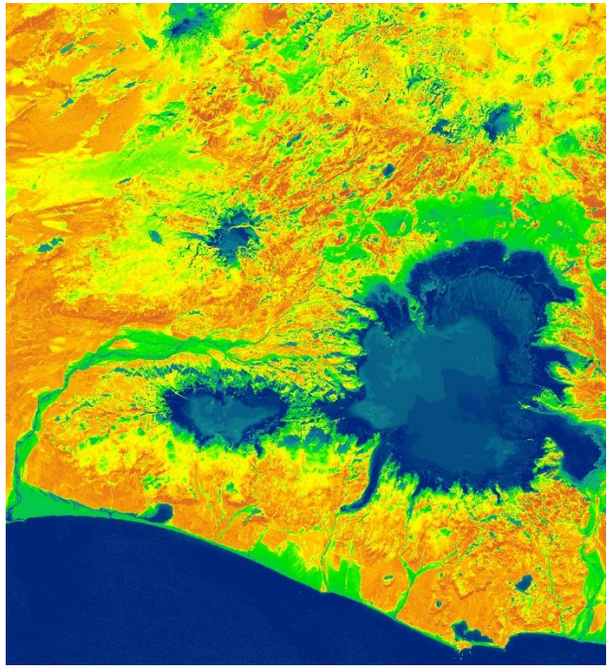
Radar imagery is quite promising as regards snow monitoring and water content in snow.

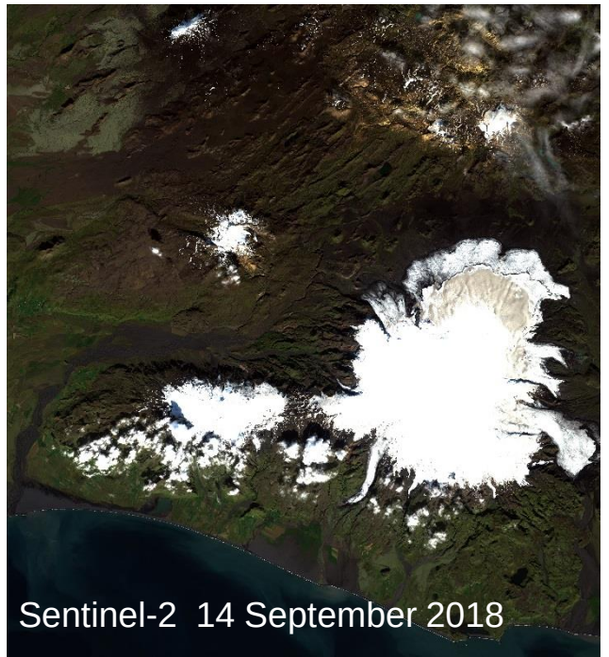
Typically, snow mapping has been carried out with multispectral images using the difference between visible and mid infrared imagery (NSDI)

Snow depth is still challenging but extent and concentration better understood.

Dust on snow and ice makes things further complicated.







Sentinel-2 14 September 2018

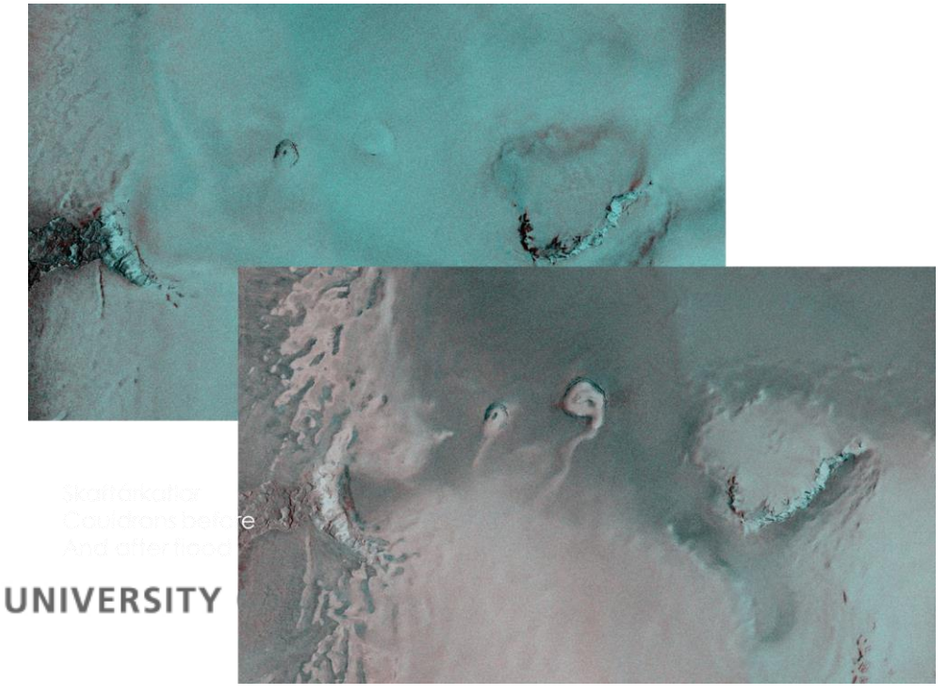
Glaciers

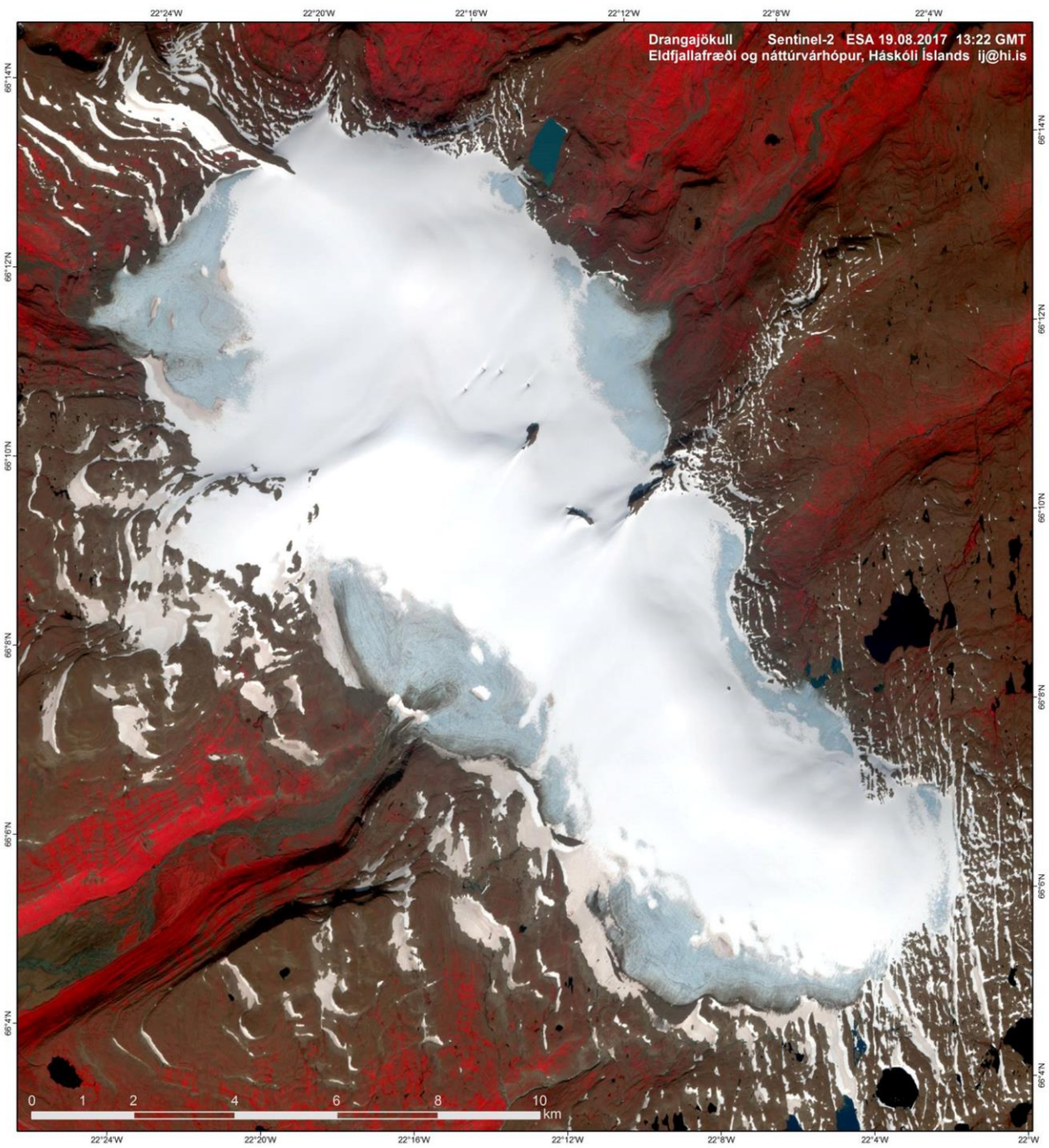
Many different features and variables to study.

Snow vs ice on Drangajökull glacier, NW Iceland NIR image

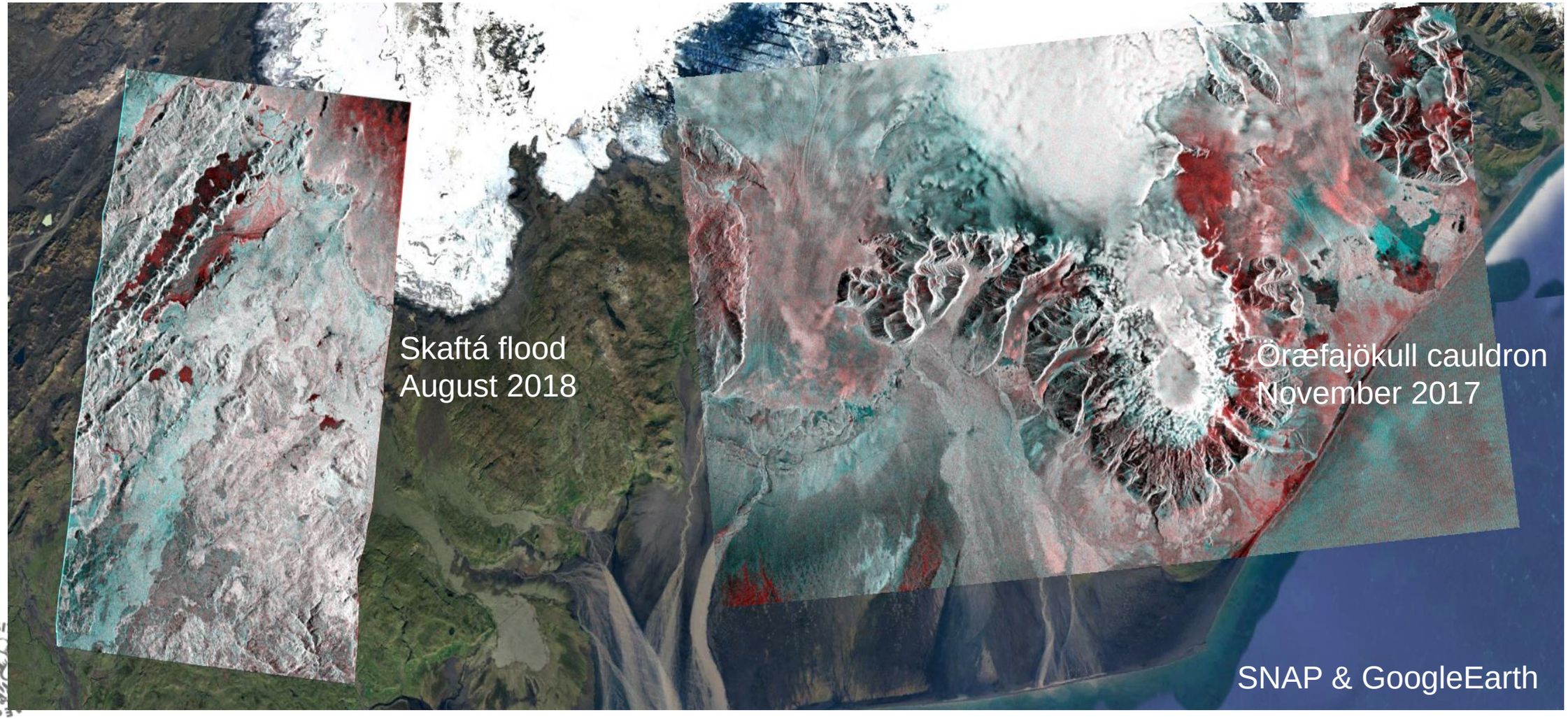
Ice cauldrons in Vatnajökull, before and after jokulhlaup 2015

Also possible to study ice movement





Flood mapping and cauldron detection

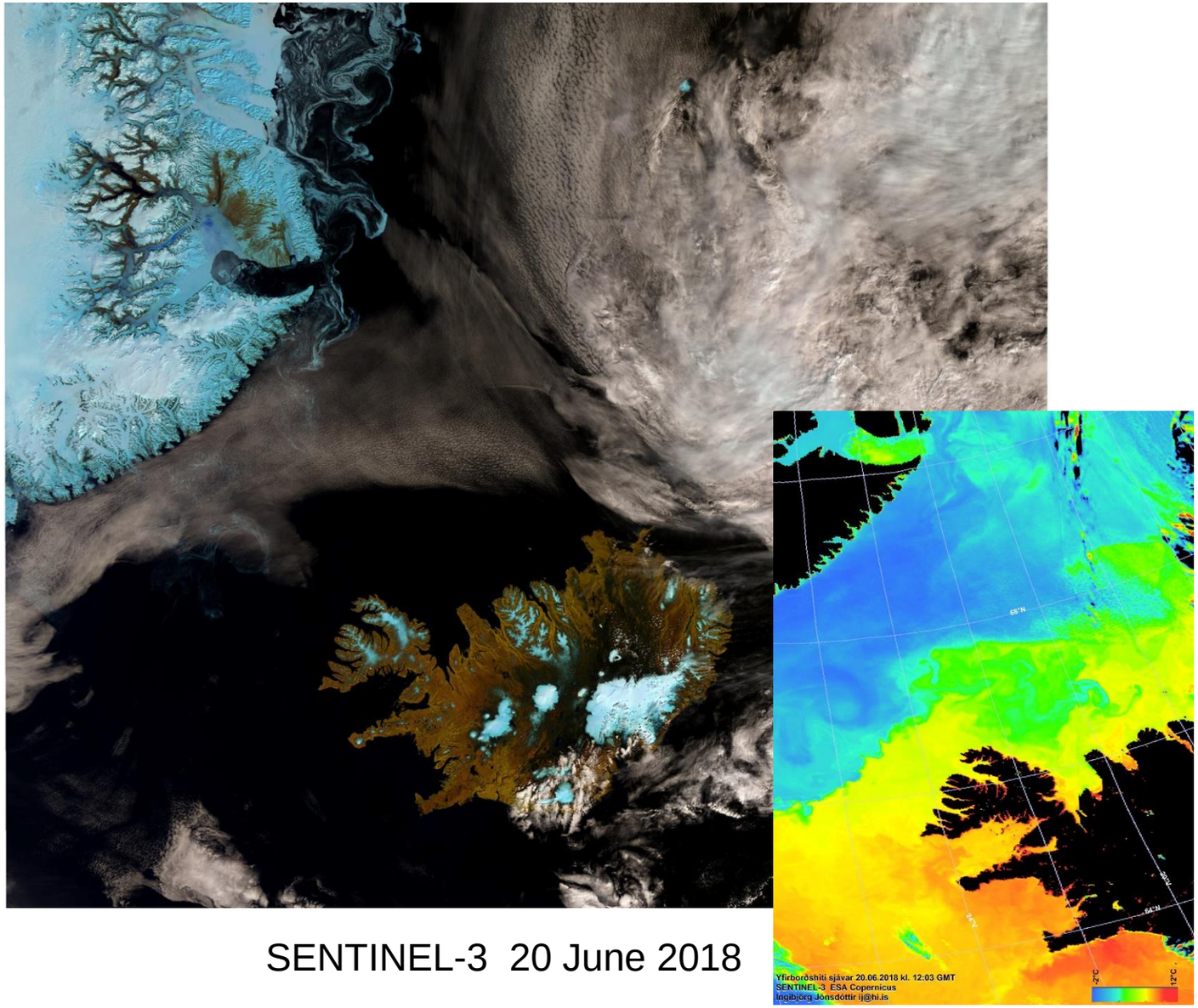


SENTINEL-3

Various uses for monitoring the oceans:

Sea Surface Temperature (SST)
Sea Surface Height
Sea ice – extent, concentration,
Ocean colour
Algae blooming

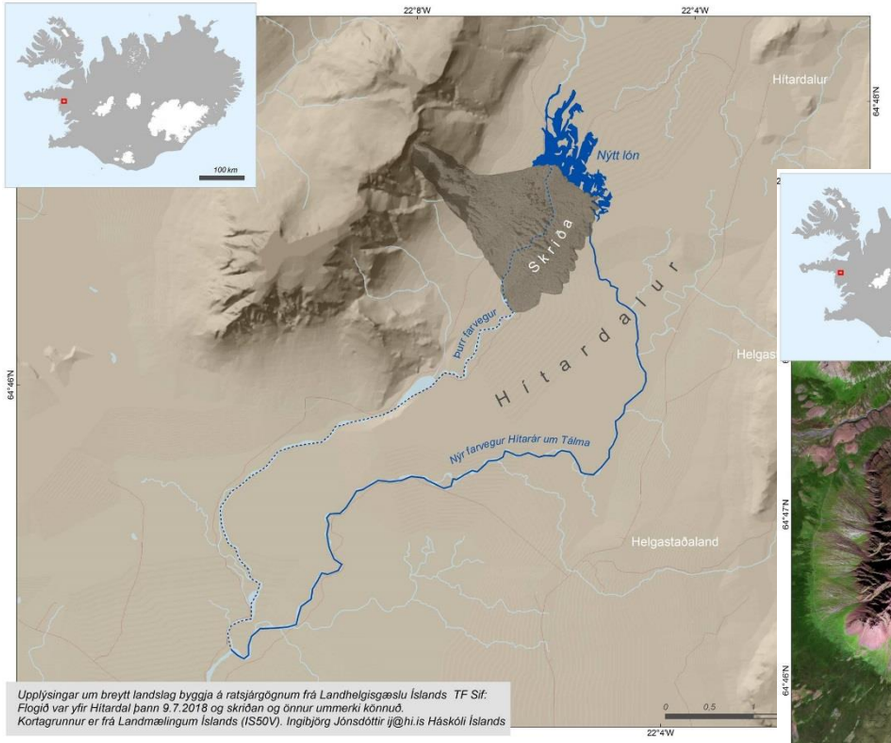
Also considerable uses for land monitoring:
Ice and snow, vegetation

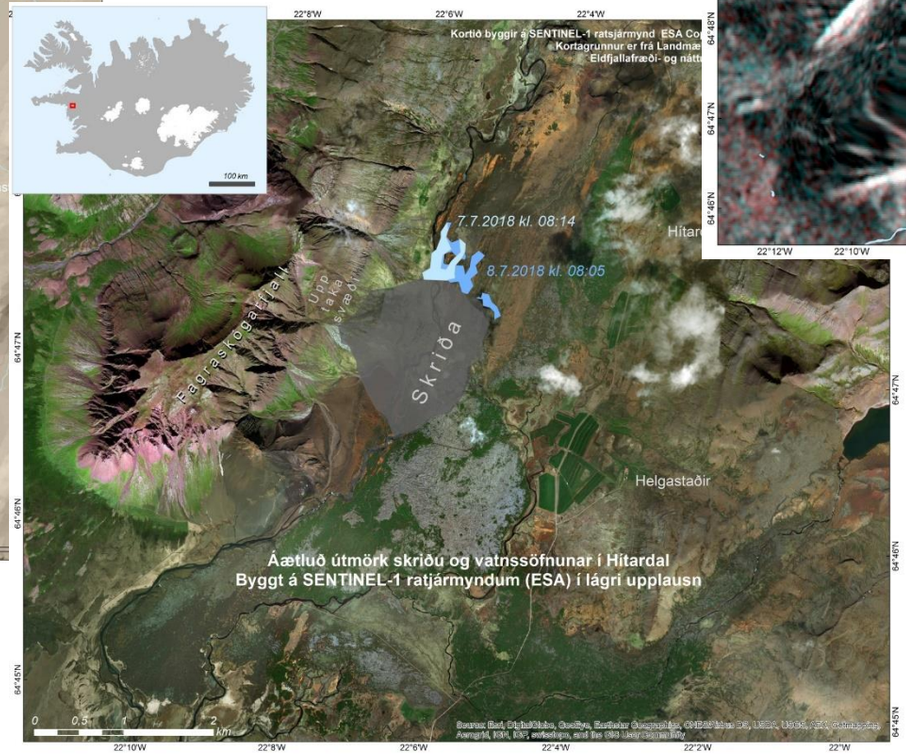


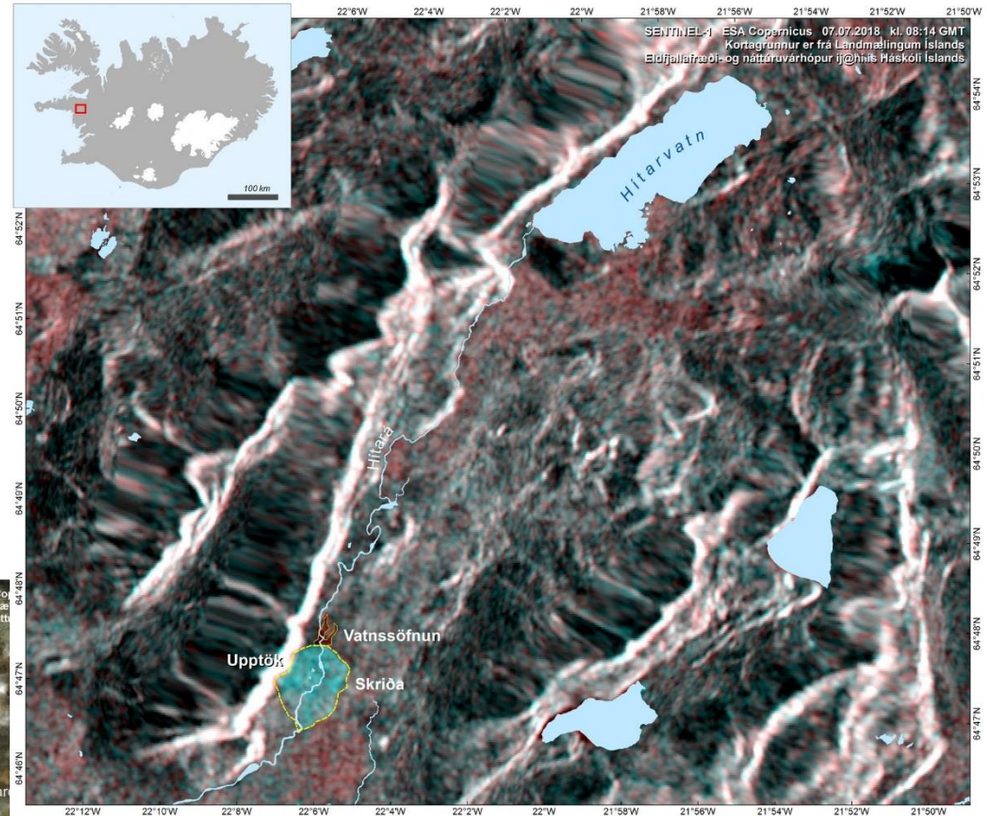
SENTINEL-3 20 June 2018

Landslides

SENTINEL-1
Change detection of landslide and water
Aerial photographs and Icelandic Coast Guard high resolution images and radar data







Landslide detected and mapped few hours after the event.
Next step, hopefully, to help prediction of areas prone to landslides or other hazard

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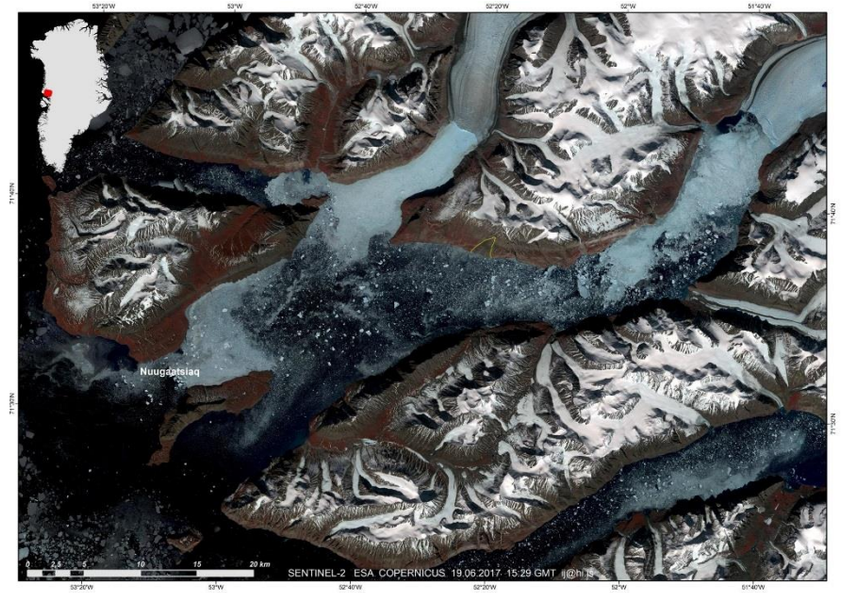
Landslide and tsunami in Greenland 2017

SENTINEL-2 and LANDSAT-8 used together



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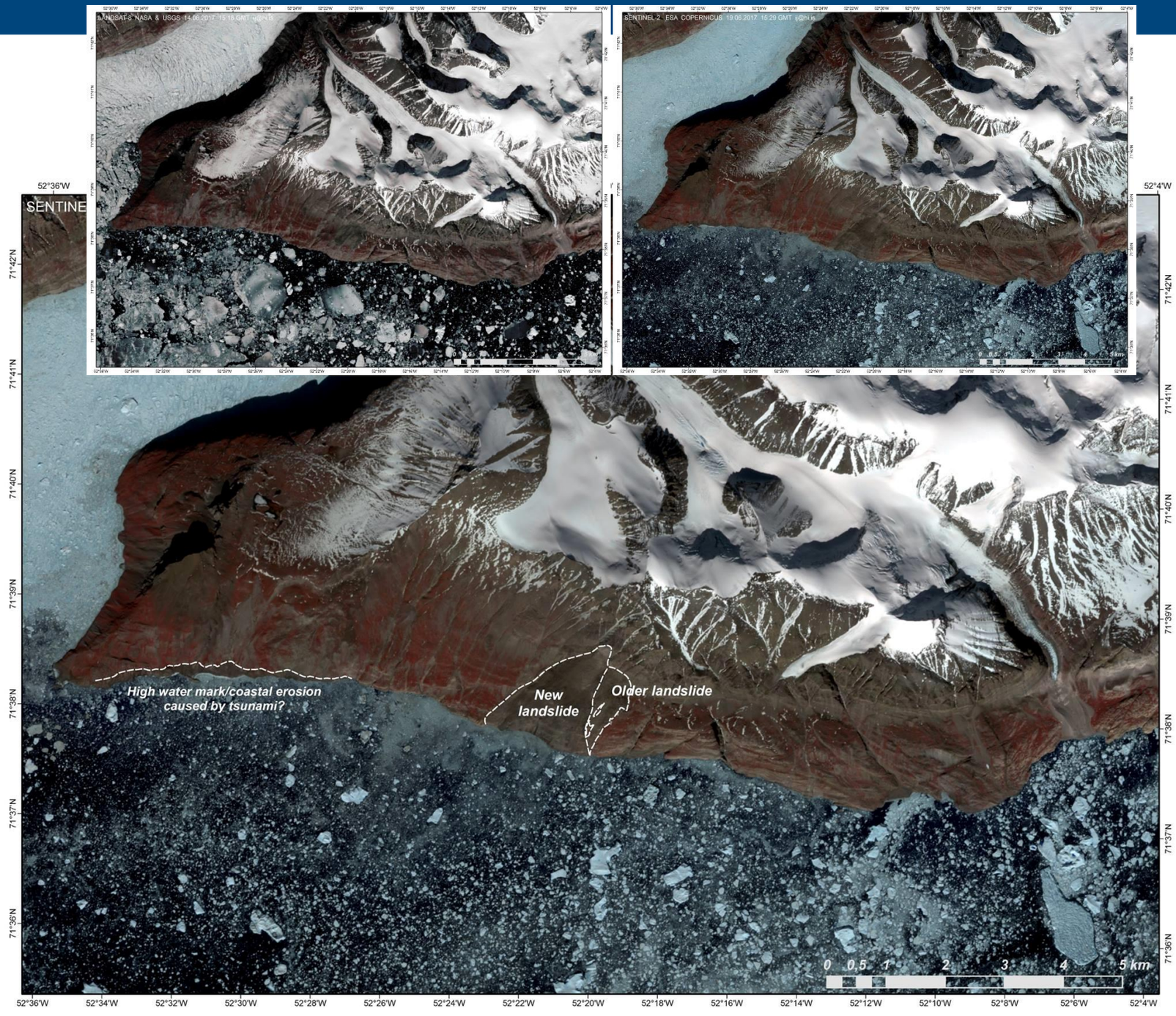

NDVI and dust storms

SENTINEL-2 multispectral images have been used to monitor dust storms in Iceland, in different band combination.

Monitoring NDVI change on a sub – seaonal scale has become possible

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Summary

- The Copernicus data is very valuable to all aspects of UIs involvement in Remote Sensing.
- The combination of higher temporal resolution of satellite data, combined with relatively high spatial resolution is extremely important for monitoring natural hazard.
- The many different uses have shown us the possibility to map the extent of hazard or affected regions, and even quantify some aspects of the change, but the next steps will be to learn more from these examples in order to be able to predict likely scenarios.
- Without the access to the Copernicus datasets, many of these tasks would simply not be possible.
- It is important to be able to study changes by comparison with earlier imagery. Now this is possible with data from all seasons. Otherwise it can be hard to detect relevant information from typical change detection.
- Remote sensing and Iceland – it is easy to say that we are few – but this is in fact more of a justification to carry out RS projects. An active RS forum in needed.
- Combination with other data sources will always be necessary, and is not a bad thing.
- Increased collaboration with Copernicus EU, ESA and NASA on projects, training and data is very welcome.

Thank you

The audience

The Copernicus Programme EU and ESA

The National Land Survey of Iceland