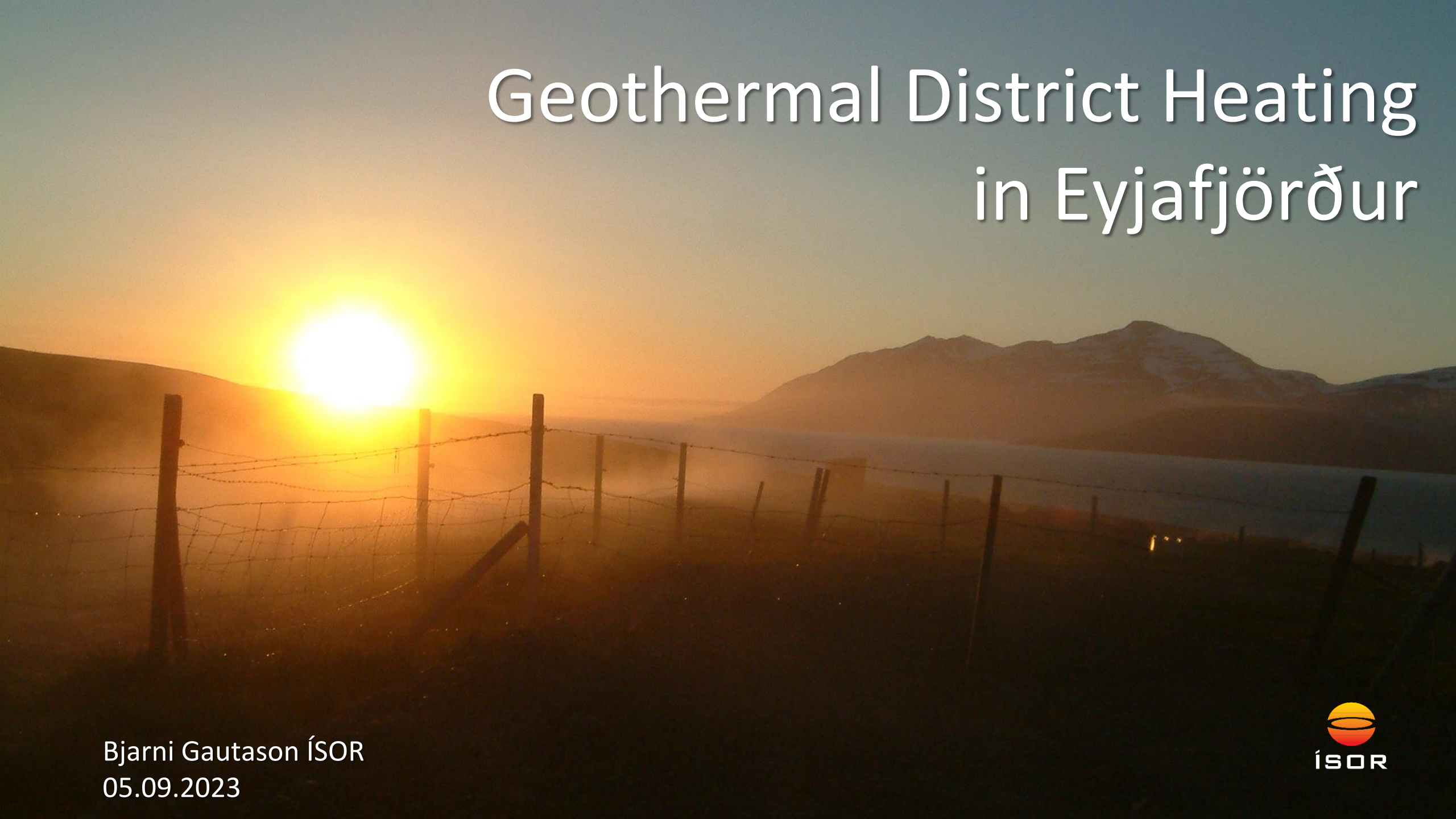
Geothermal District Heating in Eyjafjörður



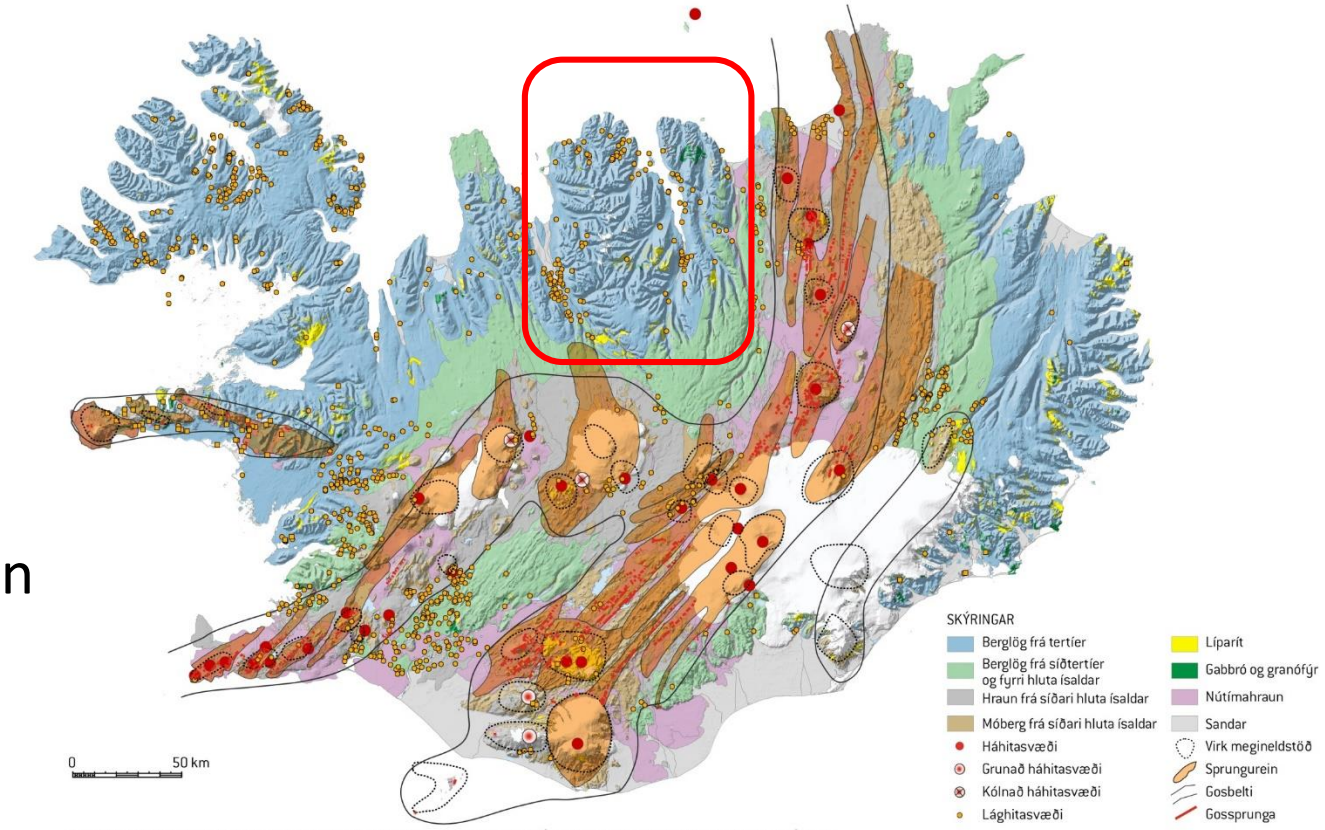
Bjarni Gautason ÍSOR
05.09.2023

OUTLINE

- Orientation – Where are we ?
- District heating in Iceland
- Overview of present-day system
- History of Norðurorka and geothermal development in Eyjafjörður
- Monitoring of utilization
- Geothermal prospecting at Hjalteyri
- Sea-water intrusion at Hjalteyri

GEOLOGICAL MAP OF ICELAND

- Miocene basalts in blue
- Pliocene basalts in green
- Pleistocene basalts in grey and subglacial hyaloclastites in brown
- Holocene lavas in purple
- Silicic rocks in yellow and gabbros in green
- High–T geoth. sys. big red dots
- Low–T geoth. sys. small orange dots



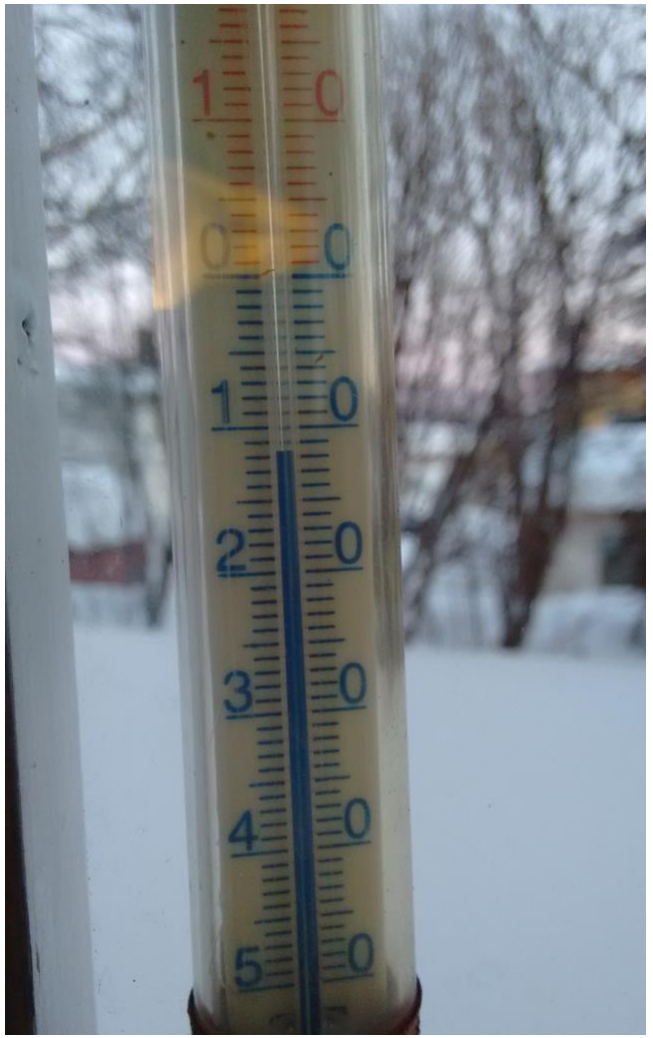
ÍSOR

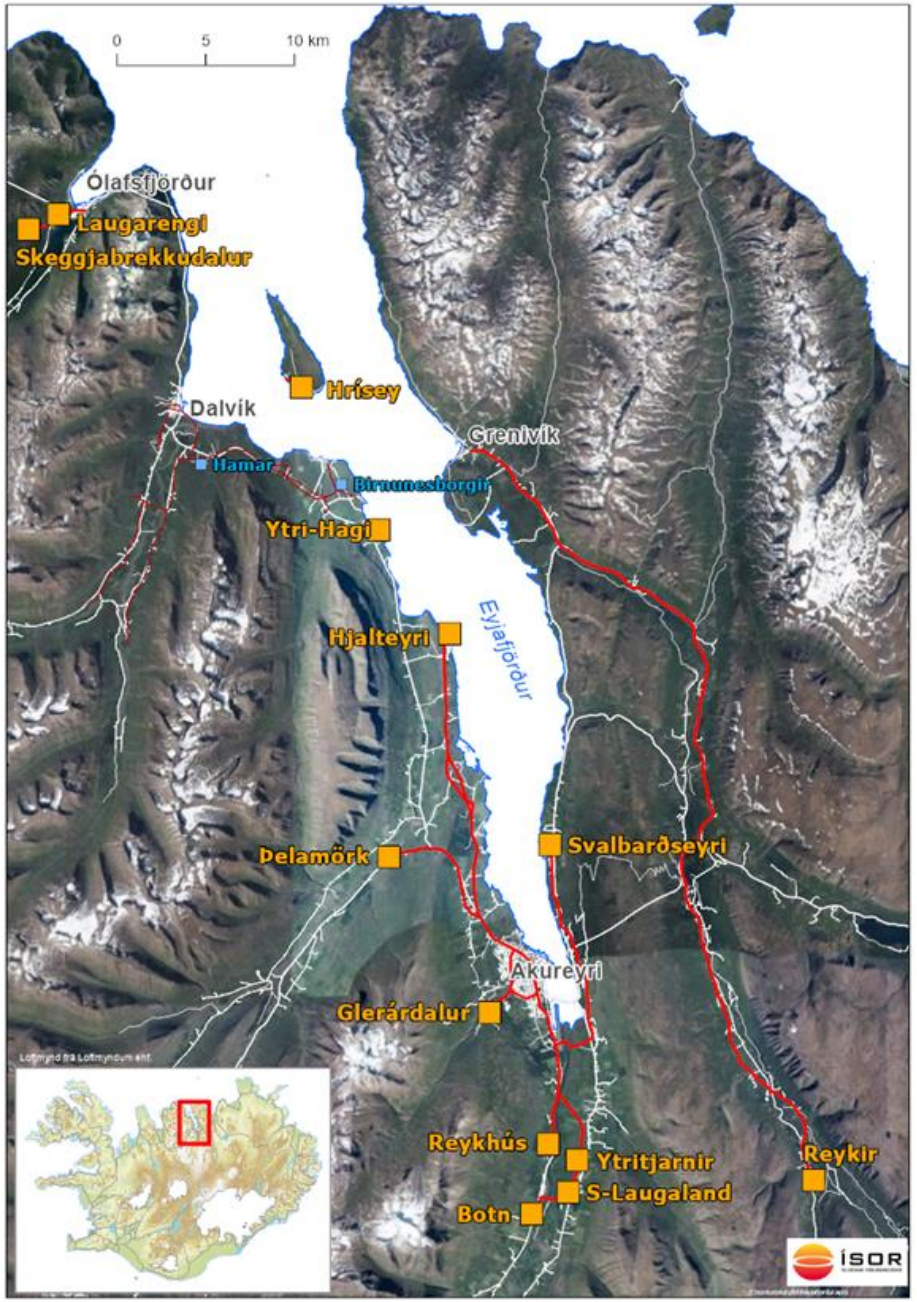
CULTURAL DATA

- Population
  - Akureyri ~19,893
  - Surrounding municipalities ~2,500 (Total > 22,000)
  - Iceland total pop. ~394,200 as of July 1st, 2023
  - Expecting to reach ~400,000 by end of 2023
- Akureyri 160+ years since established as a town
- Largest town outside the Capital region
- Educational center, industry, fishing, skiing resort, services for Eyjafjörður

ENVIRONMENTAL DATA

- Location
  - Lat 65°40’50’’ Long 18°05’22’’
- Temperature
  - January -1.9 °C - Long Term Average
  - July +10.6 °C - Long Term Average
- Precipitation
  - January ~ 55 mm - Long Term Average
  - July ~ 33 mm - Long Term Average

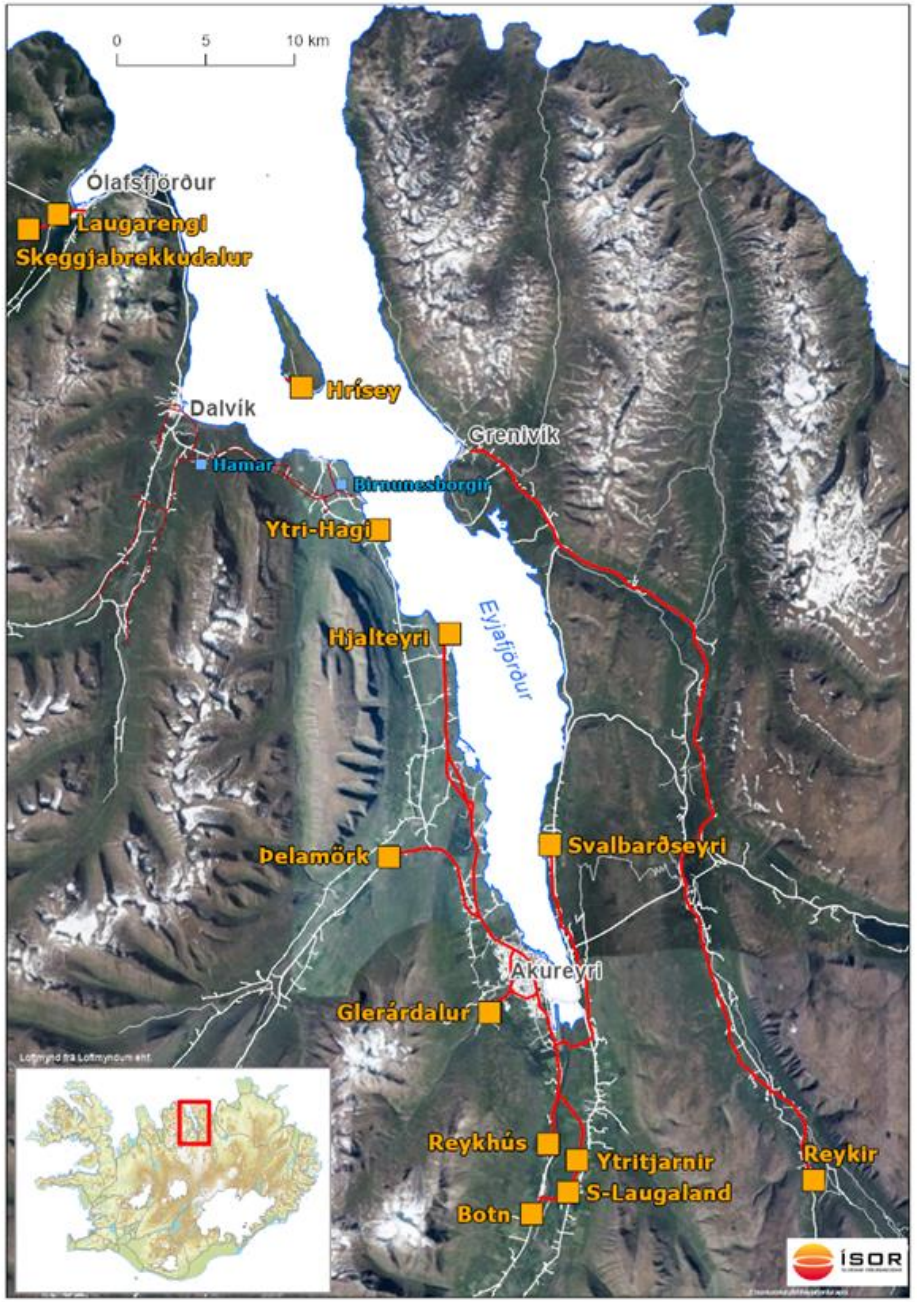




OVERVIEW OF PRESENT-DAY SYSTEM

- Production fields for Akureyri
  - Botn/Hrafnagil (south of Akureyri)
  - Syðra-Laugaland (south of Akureyri)
  - Ytritjarnir (south of Akureyri)
  - (Reykhús – re-injection only)
  - Glerárdalur (south-west of Akureyri)
  - Þelamörk (north of Akureyri)
  - Hjalteyri (north of Akureyri)
  - Svalbarðseyri (utilization re-starting)
- Re-injection (S-Laugaland & Reykhús)
- Electrical boiler, heat pumps and oil burner

ÍSOR



Norðurorka- Overview

- Three independent district heating systems
- Ólafsfjörður (part of the Fjallabyggð municipality)
  - Skeggjabrekkudalur
  - Laugarengi
- The island of Hrísey (technically part of Akureyri municipality)
  - Hrísey
- Fnjóskadalur-Grenivík
  - Reykir

ÍSOR

HISTORY OF NORÐURORKA

- First use of geothermal water for Akureyri swimming pool. Completed in 1933.
- Warm springs in Glerárgil harnessed for the pool
- From 1928 to 1971, several attempts of geothermal prospecting for geothermal for Akureyri turned out to be unsuccessful.
- Early seventies oil prices rise drastically. Renewed drive to find energy resources
- **Final attempt** at geothermal exploration in 1975 at **S-Laugaland** where warm springs were known and had been utilized

ÍSOR

HISTORY OF NORÐURORKA

- Success at S-Laugaland geothermal field. Initial discharge (artesian flow) of well **LJ-5** was **100 L/s** of **95°C**.
- District heating co. for Akureyri commences
- First houses connected in 1977
- Initially designed as a “no-return system”
- Draw down considerably greater than anticipated
- Pumping tests too short, estimates too optimistic

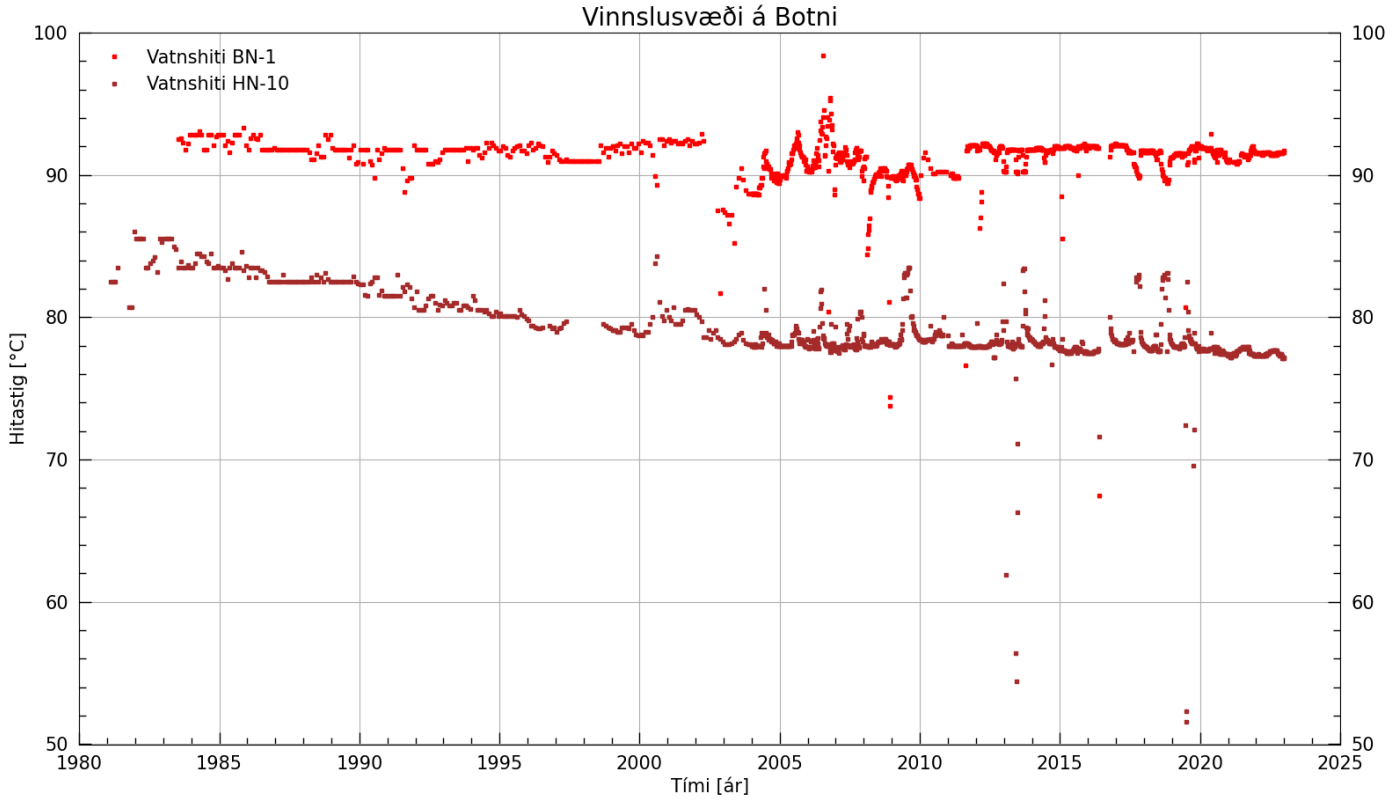
MONITORING OF UTILIZATION

- Careful monitoring of energy production and the resulting responses of utilized geothermal systems involves:
  - Pressure (water-level),
  - Water-temperature
  - Chemical content
- Makes it possible to assess, and reassess, the energy potential of systems.
- Careful monitoring also makes it possible to foresee undesirable changes:
  - Inflow of cold water (fresh/saline)
  - Makes it possible to react in time.

ÍSOR

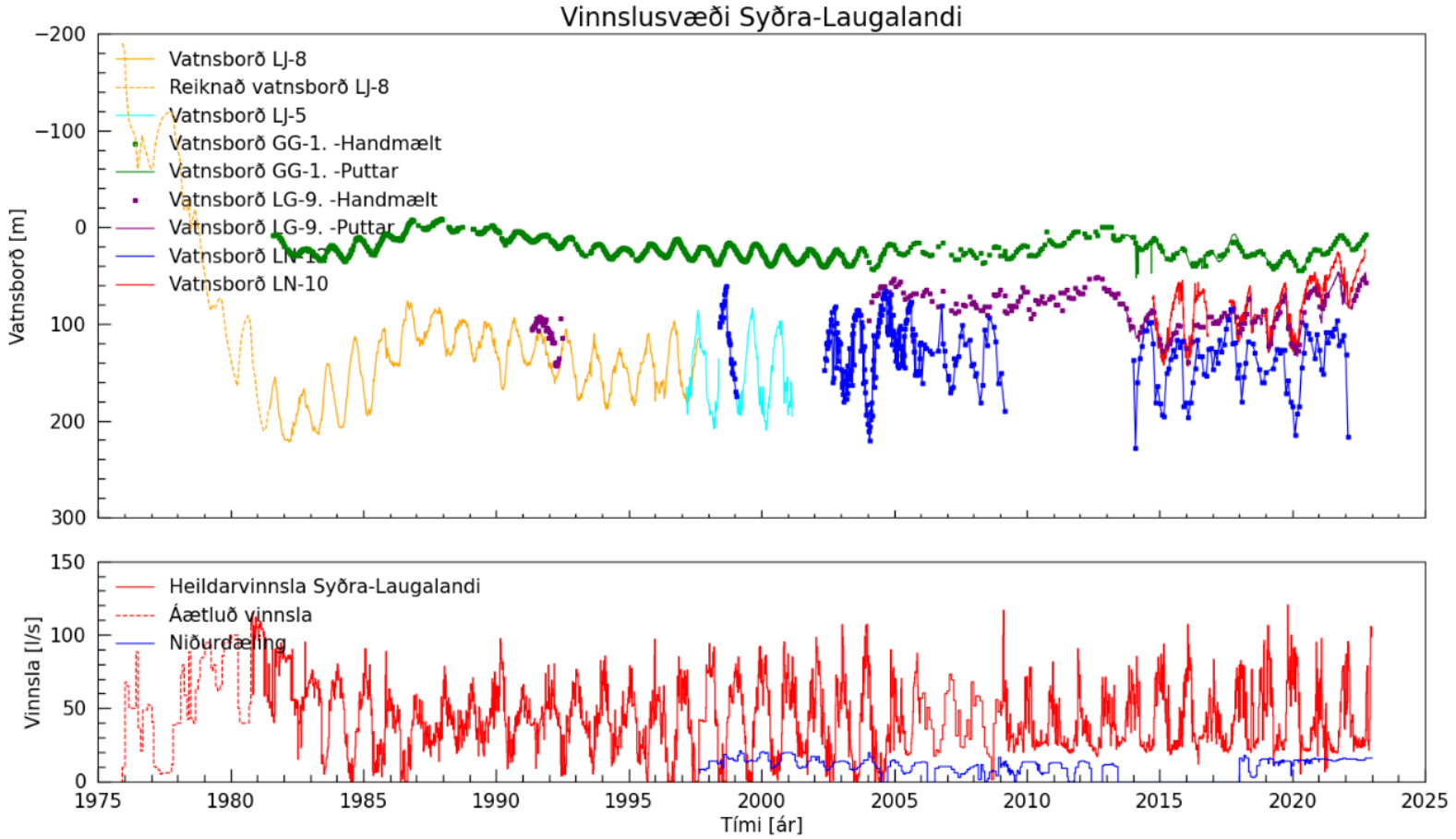
TEMPERATURE

- Botn-Hrafnagil T data
- HN-10 has declined in T
- BN-1 is more stable
- Both wells go to artesian flow if production is stopped
- T increases in HN-10!



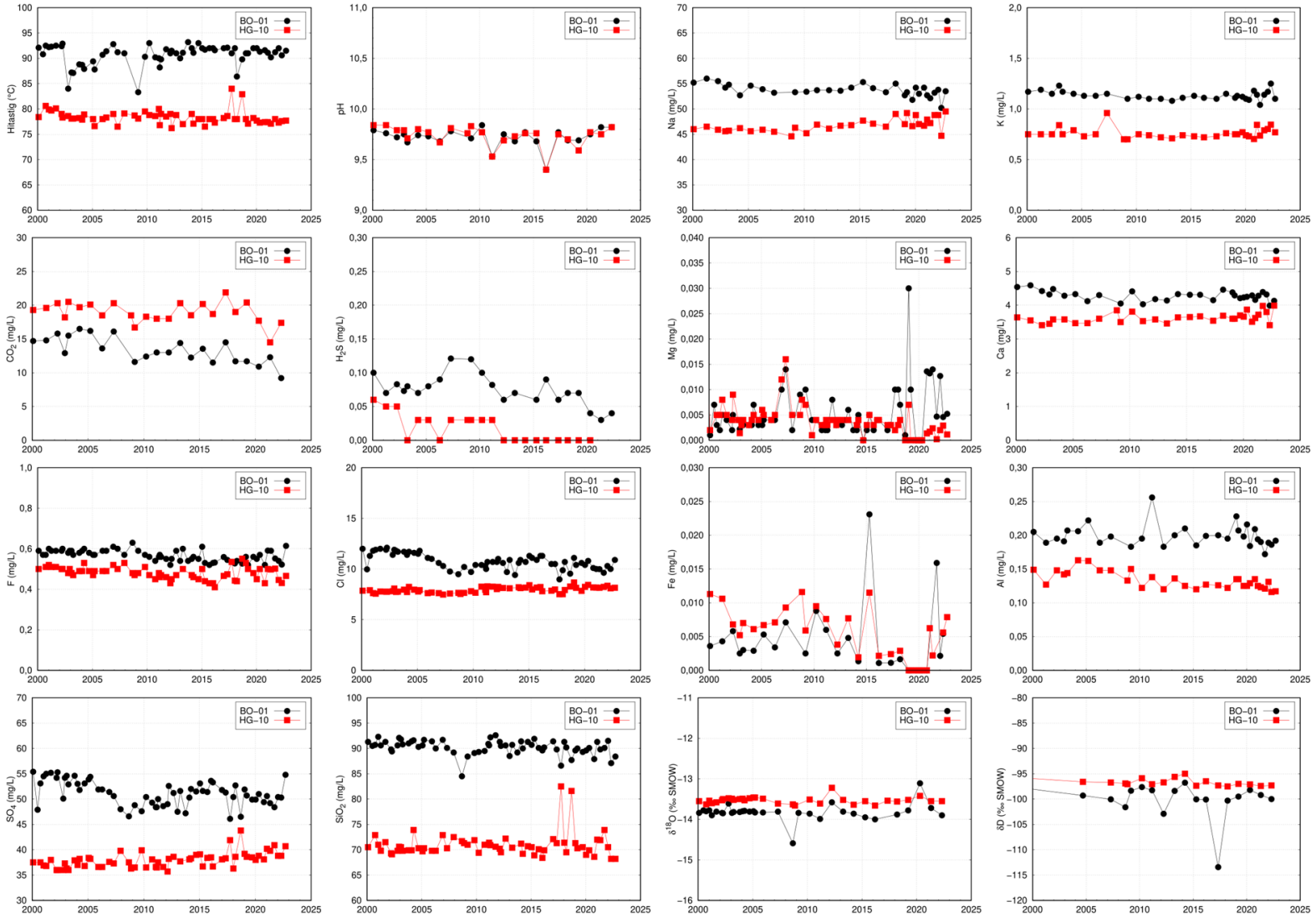
PRESSURE AND PRODUCTION

- Production peaks in winter
- Note steady state water levels (pressure), after initial drwdown, for several decades
- Re-injection intermittent



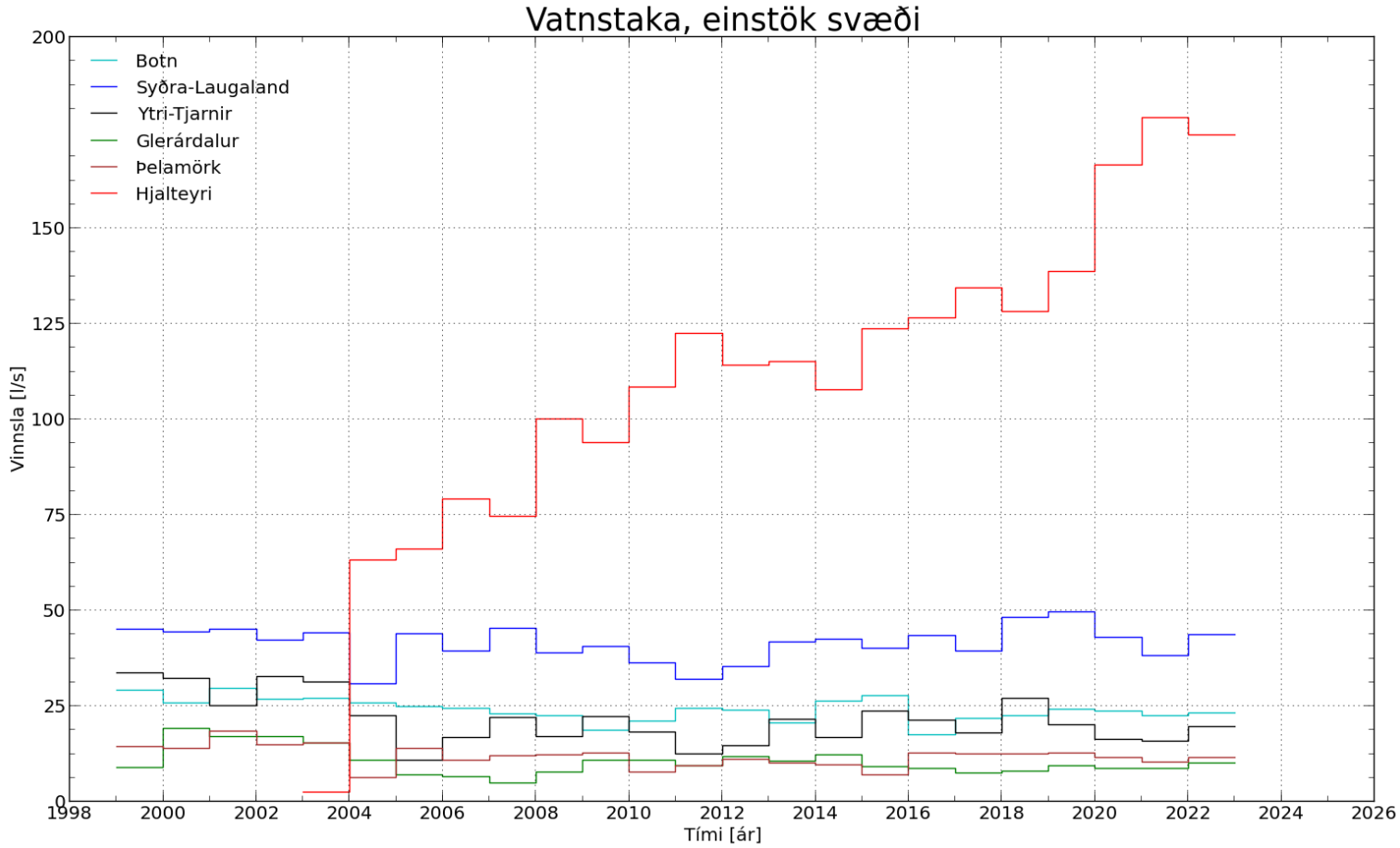
CHEMISTRY

- All production wells sampled annually in the spring for a complete chemical makeup
- Most produciton wells sampled (winter and fall) for a partial analysis



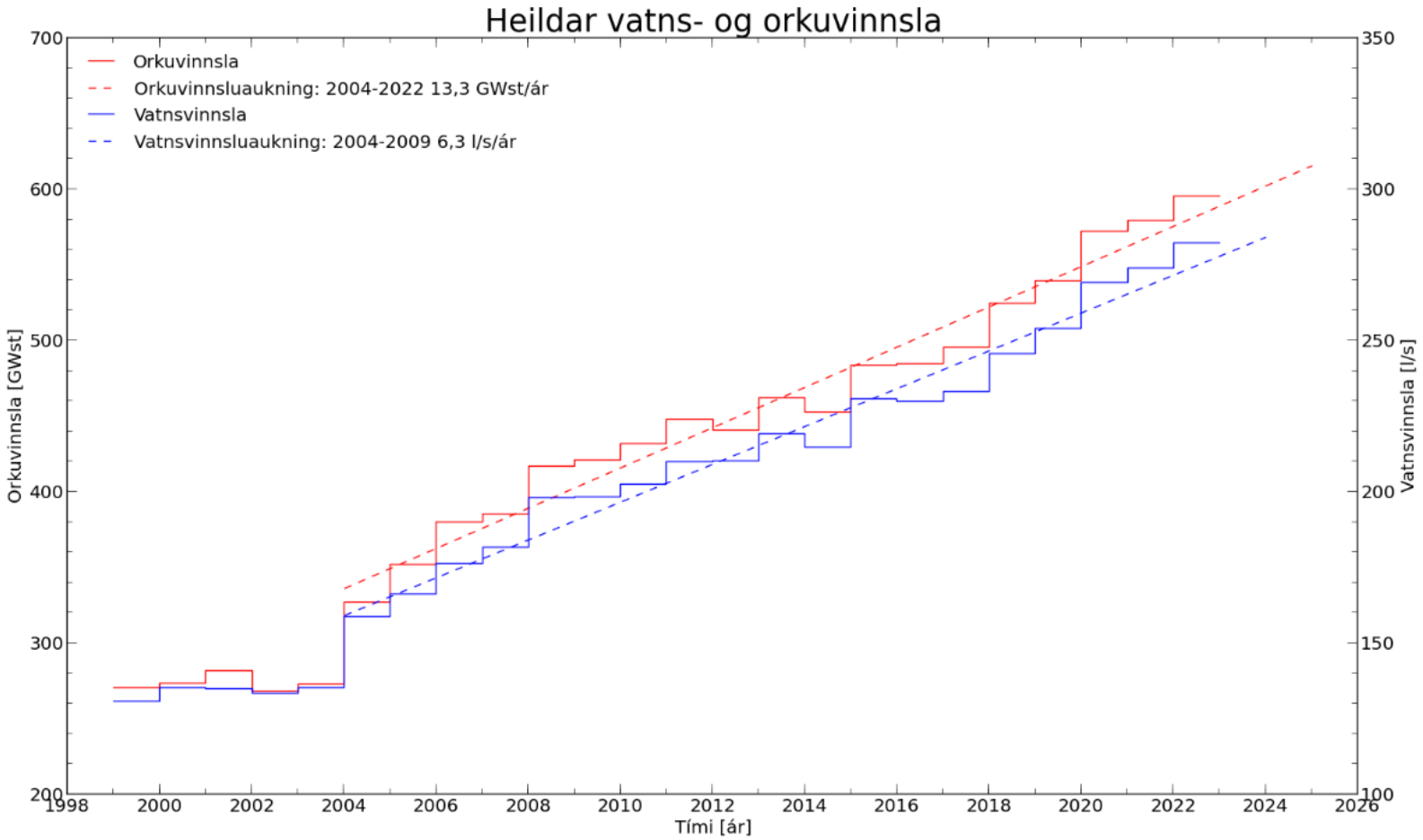
PRODUCTION (AVERAGE ANNUAL) PER FIELD

- Note the important contribution from Hjalteyri
- All increase in energy use for 2004 has been met with increased production at from Hjalteyri



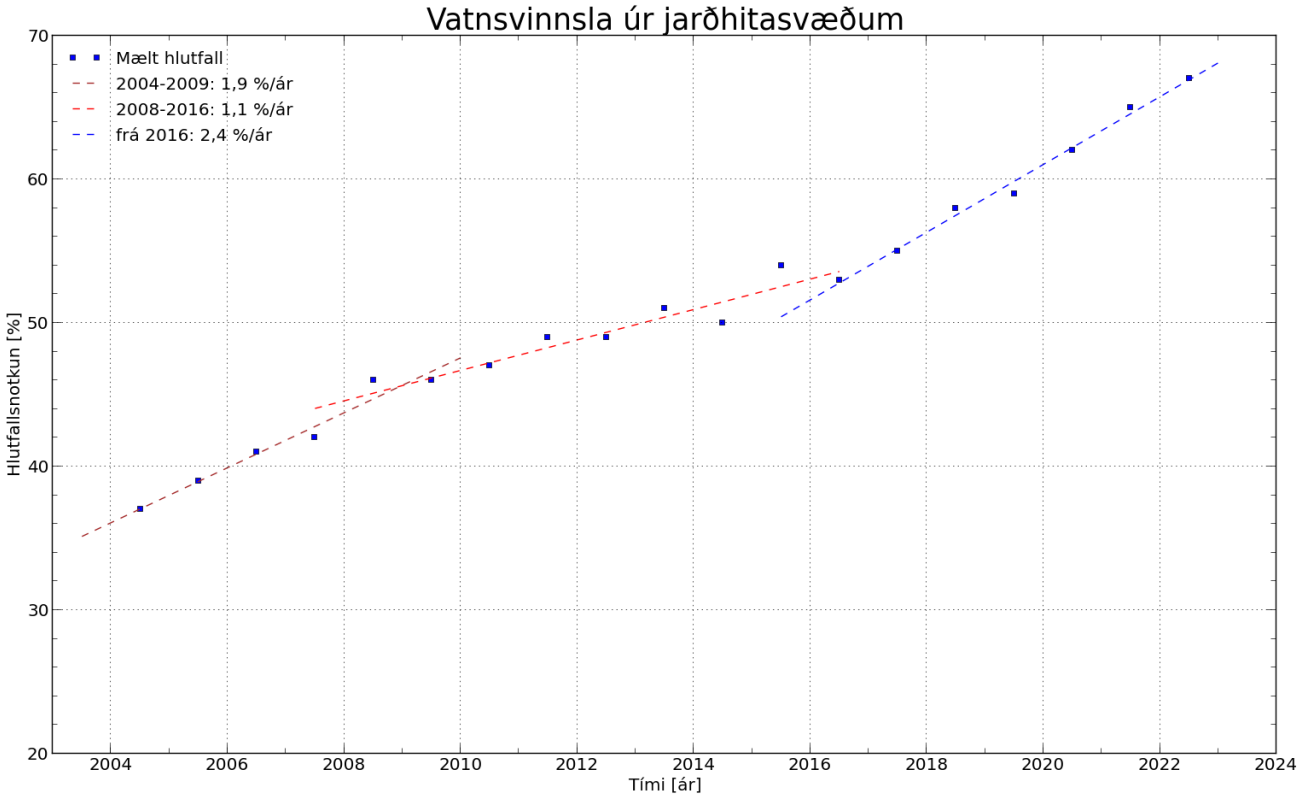
ENERGY AND TOTAL WATER PRODUCTION

- Energy production inreases on average by 13.3 GWh annually (red line)
- Water production inreases on average by 6.3 L/s annually (blue line)

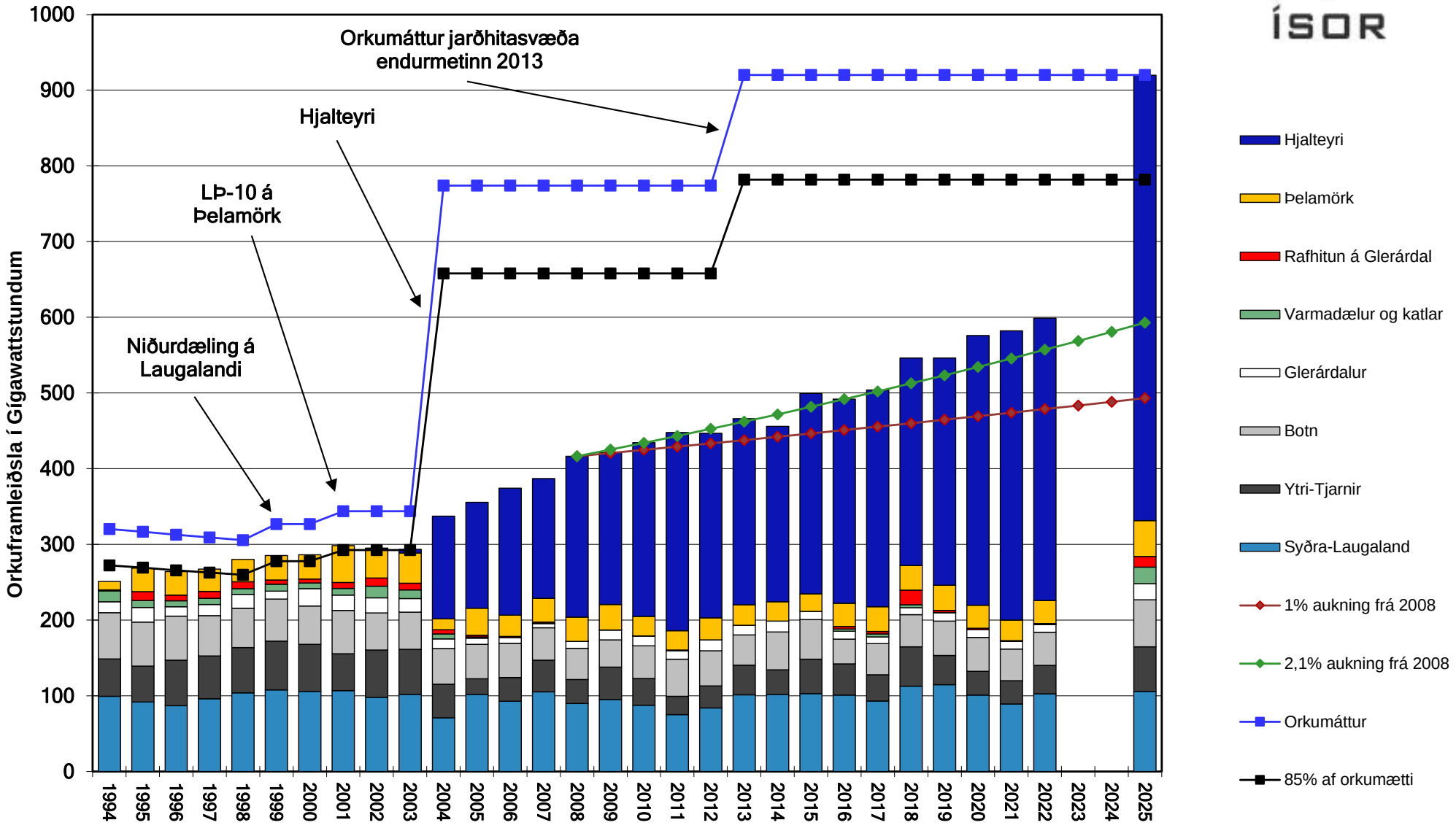


PROPORTIONAL INCREASE IN WATER PRODUCTION

- Annual increase in hot-water production
- From 2004 to 2009 1.9% increase
- From 2009 to 2016 1.1% increase
- From 2017 to 2022 2.4% increase



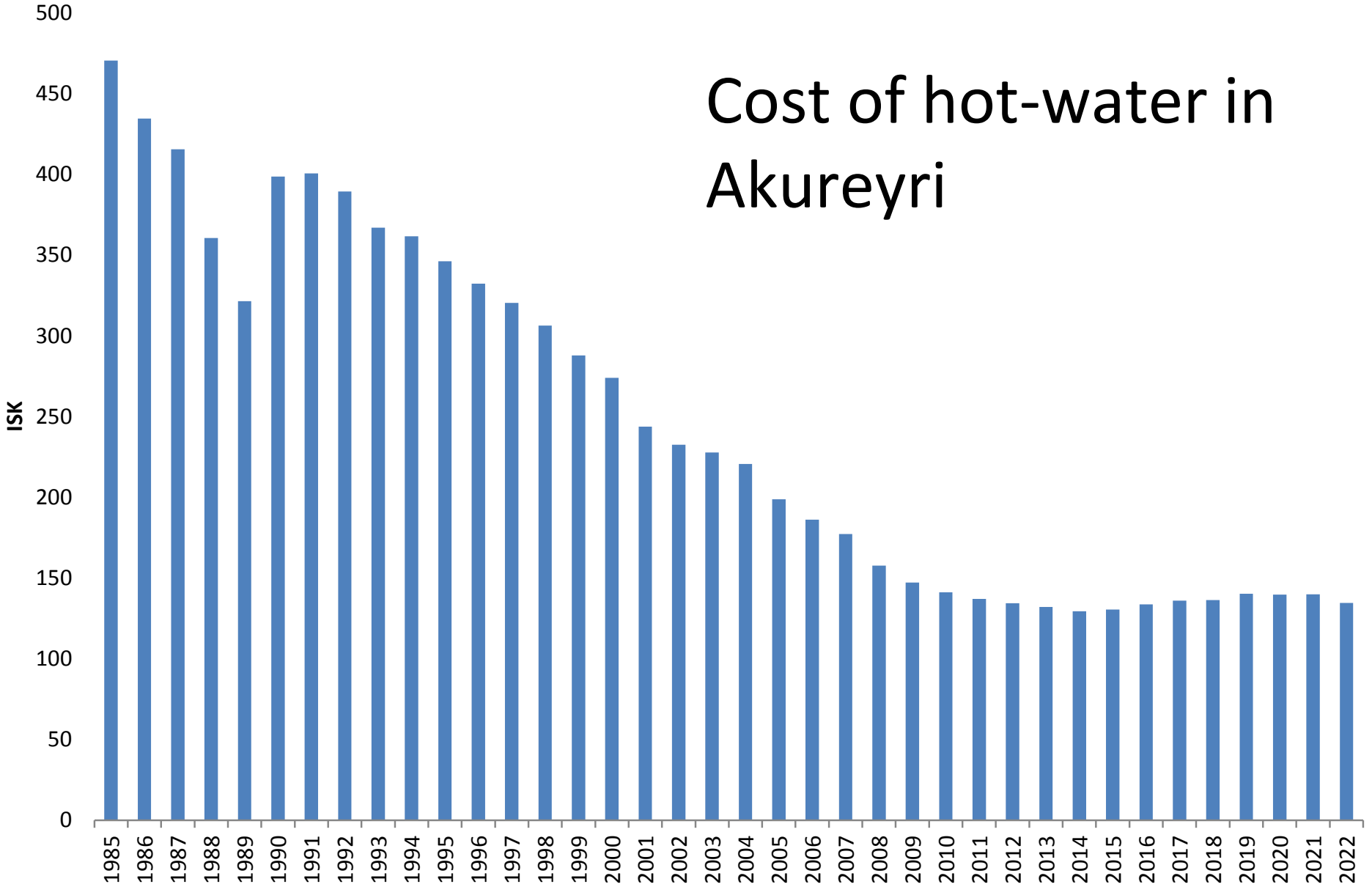
Orkunotkun, orkuþörf og orkumáttur hitaveitu Norðurorku.



POPULATION AND HOUSING

- Rate of increase in both no. of inhabitants and m^3 of housing has increased in the last few years (since 2017)
- Energy use per capita and energy use per m^3 housing has increased since 2017 (bottom panel)

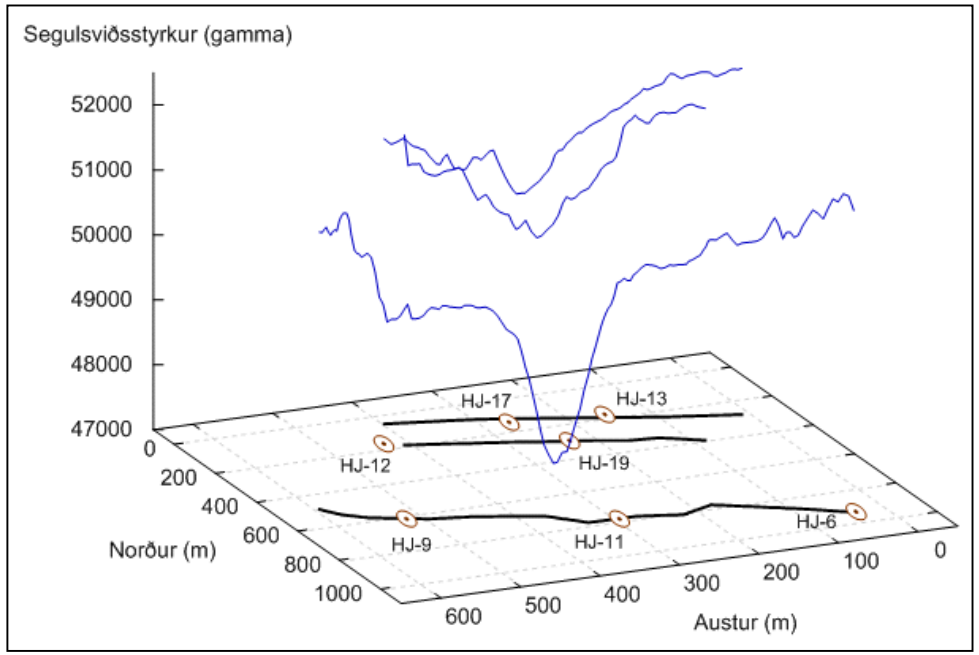
Cost of hot-water in Akureyri

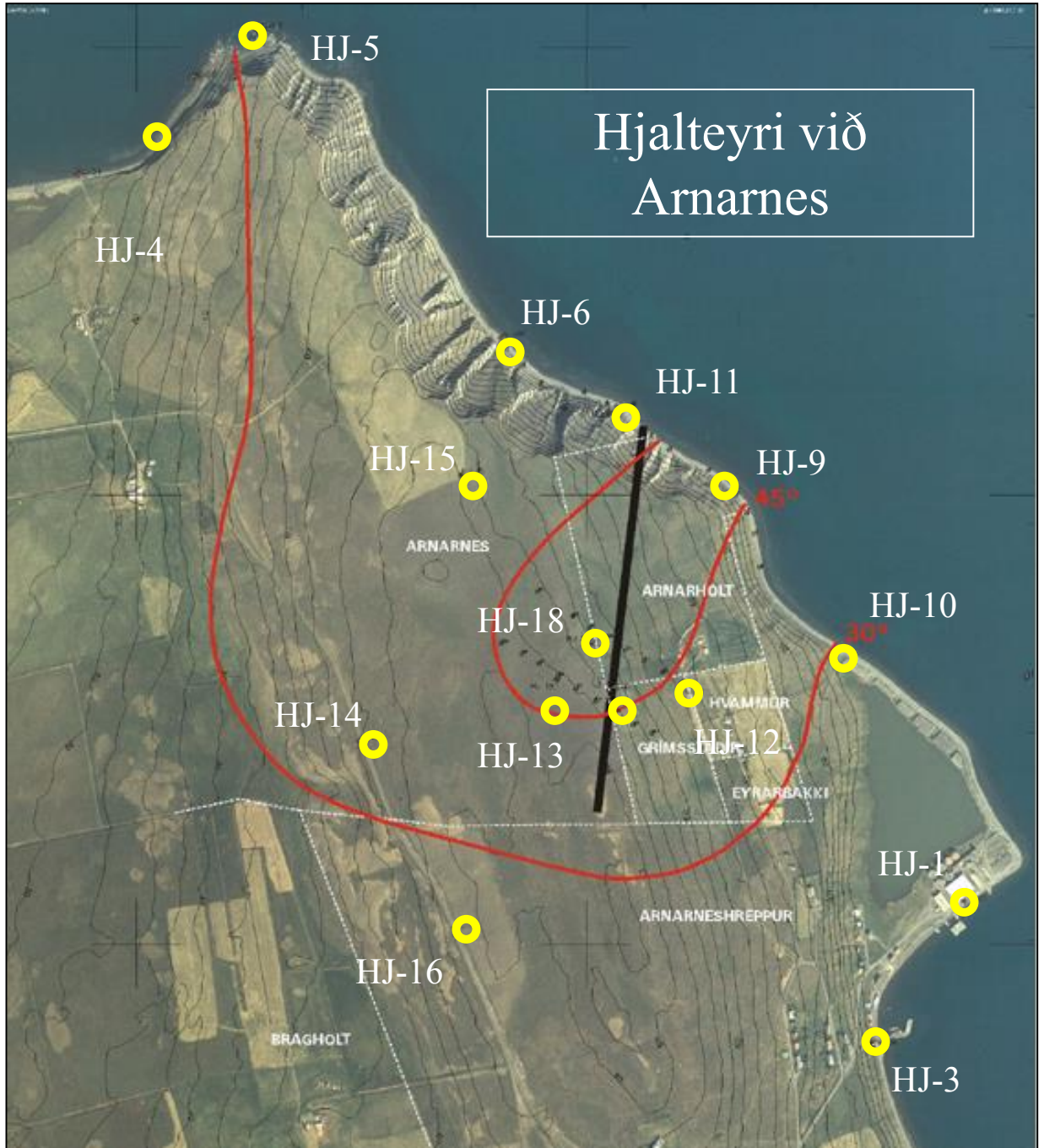


GEOTHERMAL PROSPECTING AT HJALTEYRI

- First well HJ-1 drilled to obtain sediment filtered seawater for fish farming
- Temperature gradient higher than expected
- Municipality of Arnarneshreppur initiates prospecting for source in 1998
- ISOR (ROS) scientific advisor
- Initial emphasis on shallow wells, Temperature gradient
- Geological mapping; Ground magnetic survey; Chemical analyses of water
- Mapping of seismic activity

Prospecting at Hjalteyri



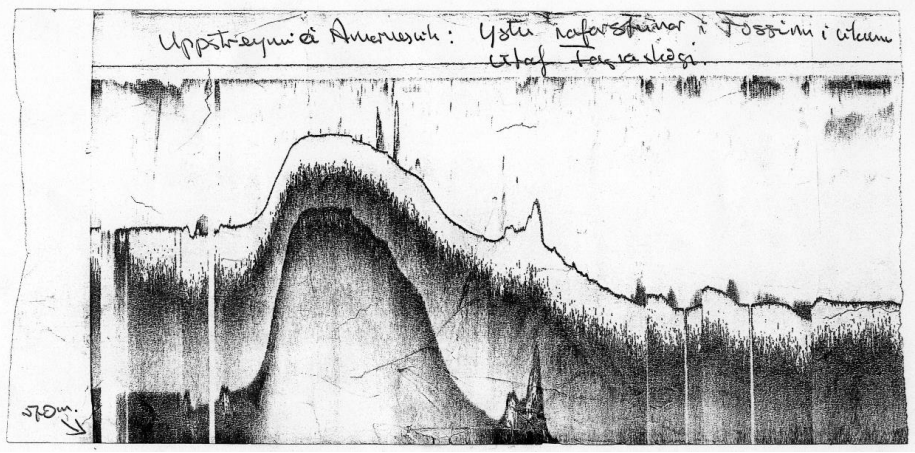


PRODUCTION WELLS AT HJALTEYRI

- Drilling of **HJ-19** spring 2002
  - 1450 m vertical well
  - Surface casing to 50 m (14")
  - Production casing to 400 m (10¾ ")
  - Open hole (8 ½ ")
- Drilling of HJ-20 in january 2005
  - 1280 m vertical well
  - Surface casing to 50 m (18 ⅝")
  - Production casing to 350 m (13⅜ ")
  - Open hole (8 ½ ")
- Drilling of HJ-21 in january 2005
  - 1280 m vertical well
  - Surface casing to 50 m (18 ⅝")
  - Production casing to 350 m (13⅜ ")
  - Open hole (9 ⅝ ")

ÍSOR

DISCOVERY OF THE STRÝTAN FIELD



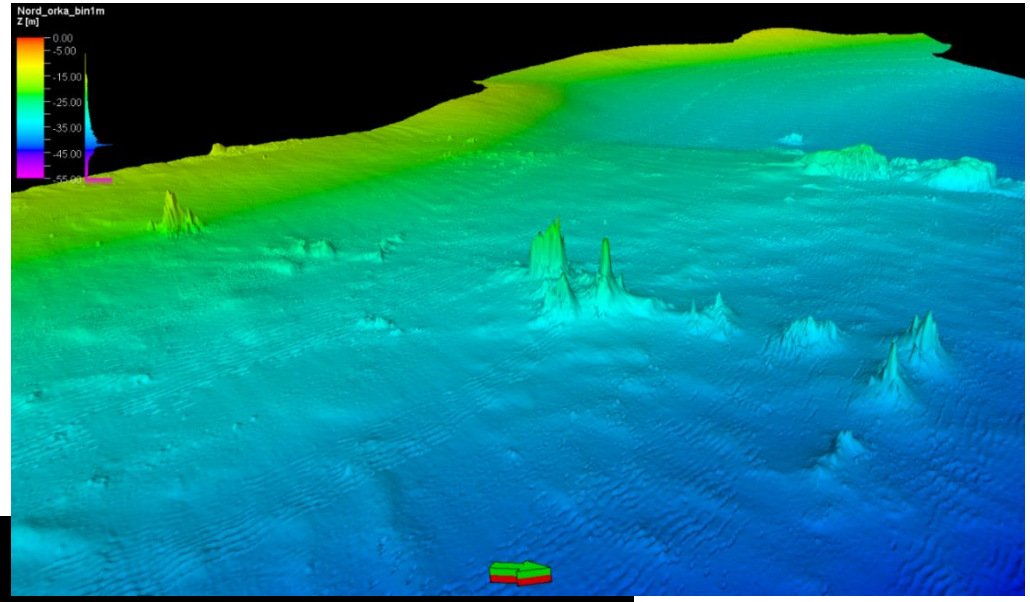
Copy of printout from simple sonar on-board the vessel „Trausti EA-244“ owned by Þorvaldur Hermansson who supplied the copy.

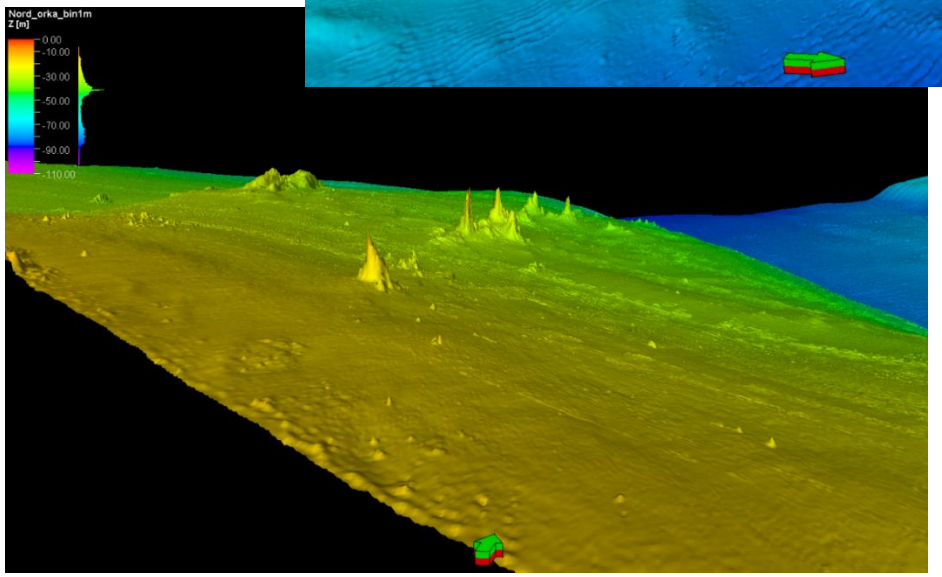
- In august 2004 the research vessel **Baldur** (Sjómælingar) was contracted by Norðurorka to do Multi-Beam bathymetry North and East of Arnarnes to find a suitable path for the submarine pipeline
- We were also hopeful of finding some manifestations of geothermal activity due to reports from local fishermen

ÍSOR

DISCOVERY OF THE STRÝTAN FIELD

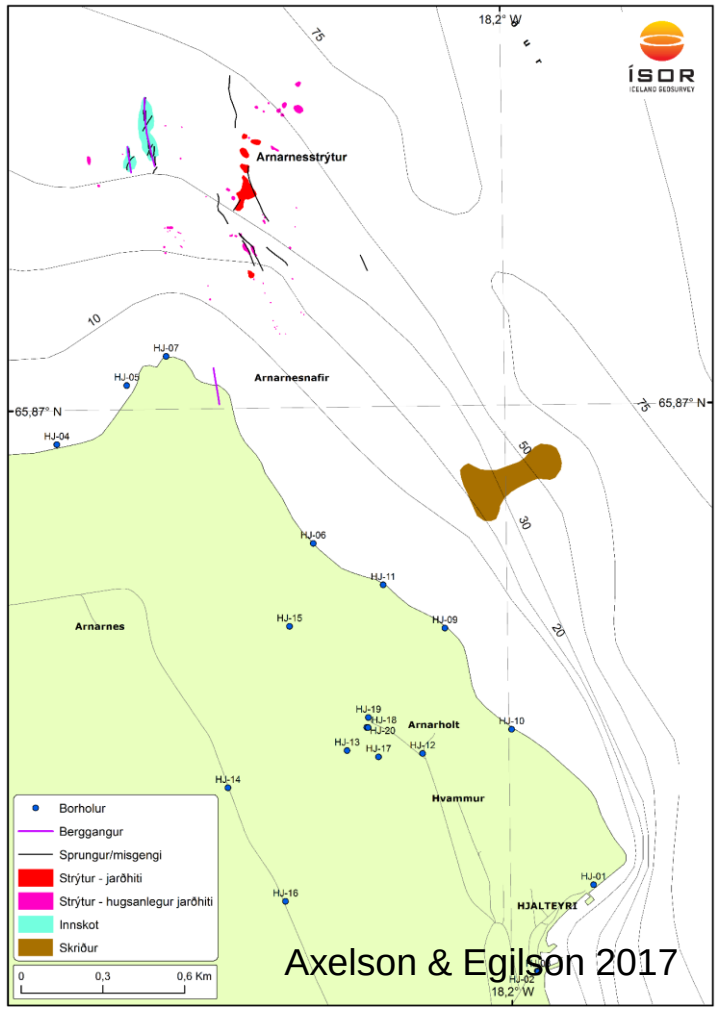
- Friday the 20th of August 2004, Baldur came to Akureyri after 2 days of gathering data with big news!
- A linear row of cones trending just E of N-S extending for more than 500 m was discovered
- Sunday the 22nd of August 2004, first dive and sampling of fluid





DISCOVERY OF THE STRÝTAN FIELD

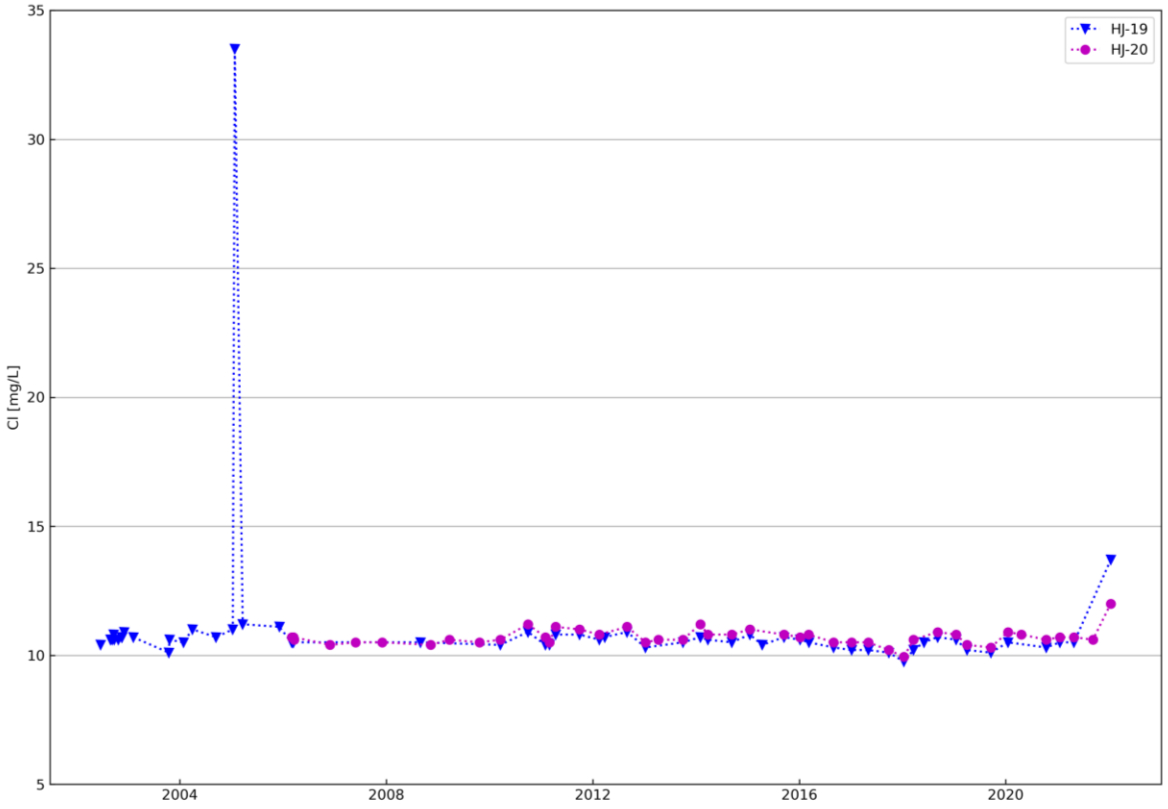
Photos: Erlendur Bogason

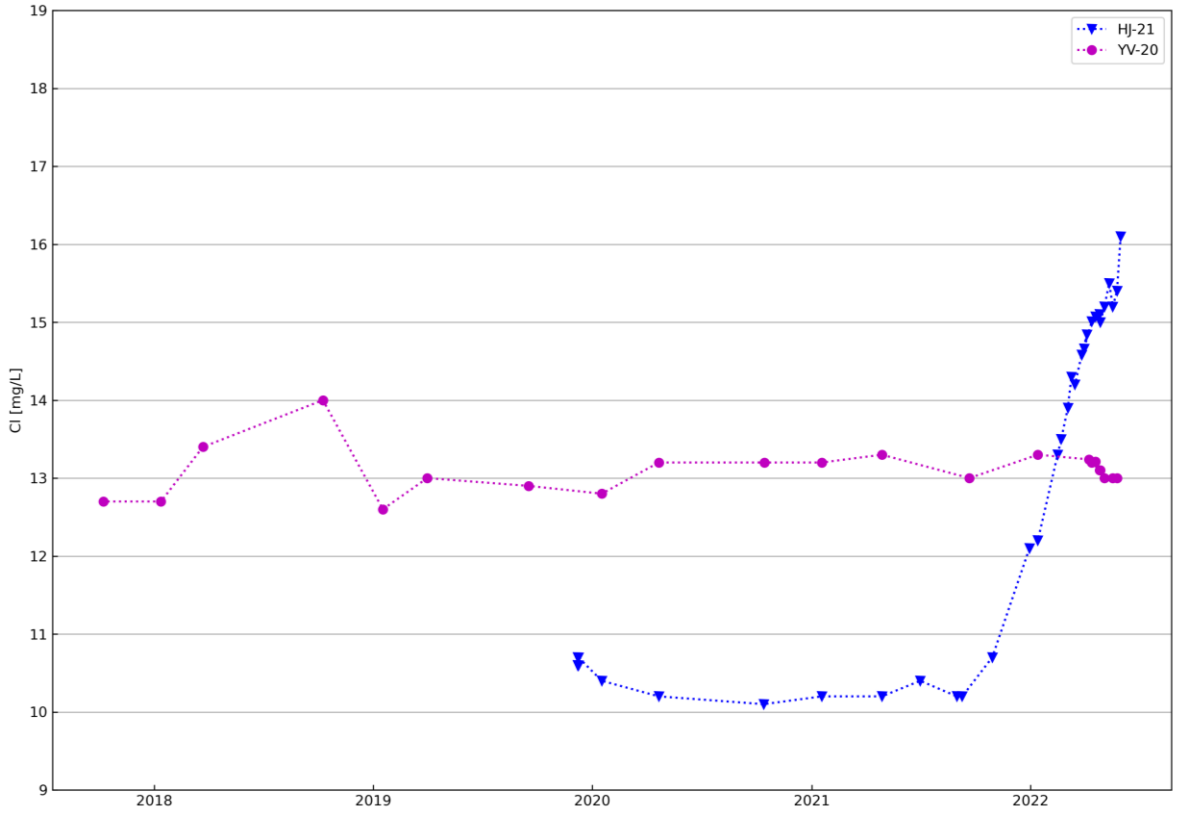


Axelson & Egilson 2017

ÍSOR

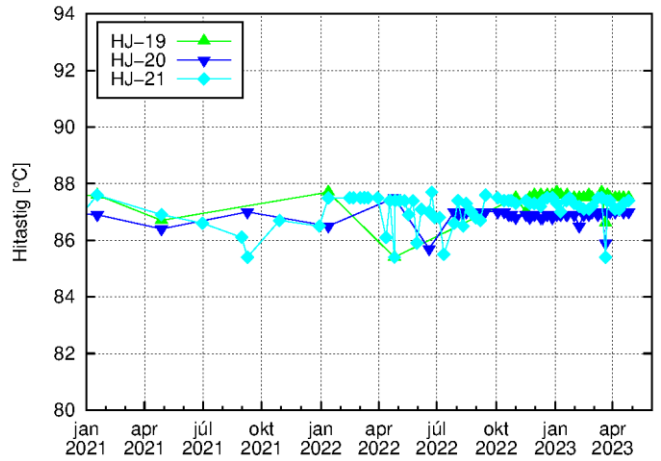
SEA-WATER INTRUSION AT HJALTEYRI



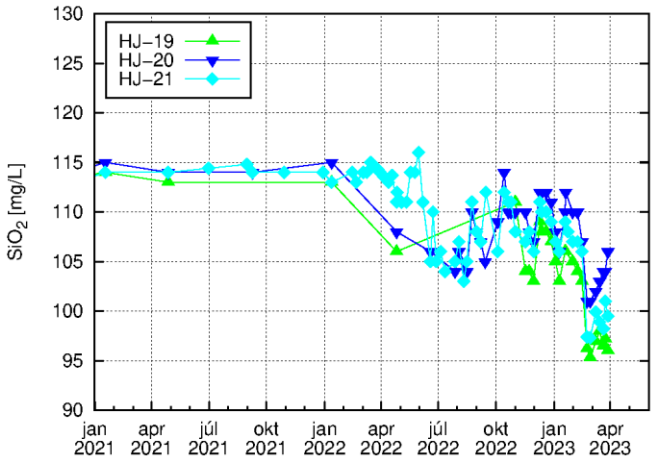


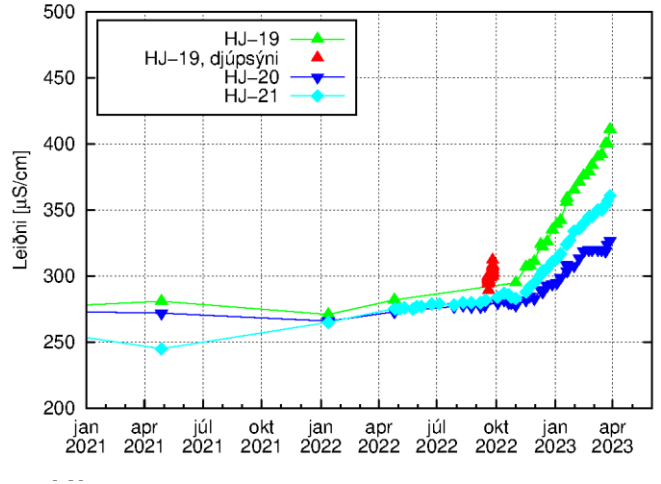
Fluid chemistry:

Hitastig

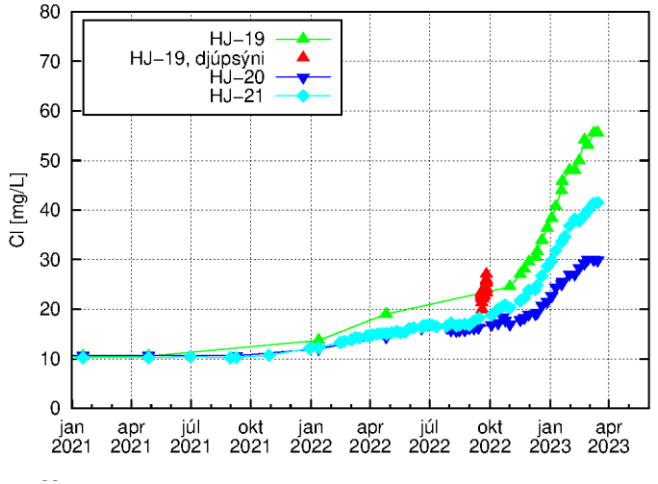


Kísill





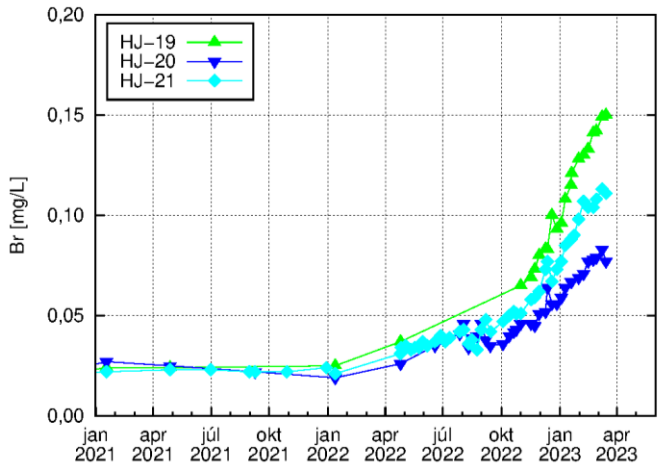
Leiðni



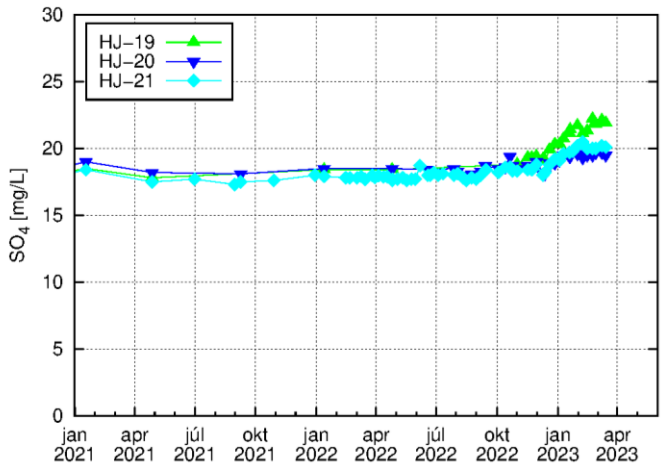
Klóríð

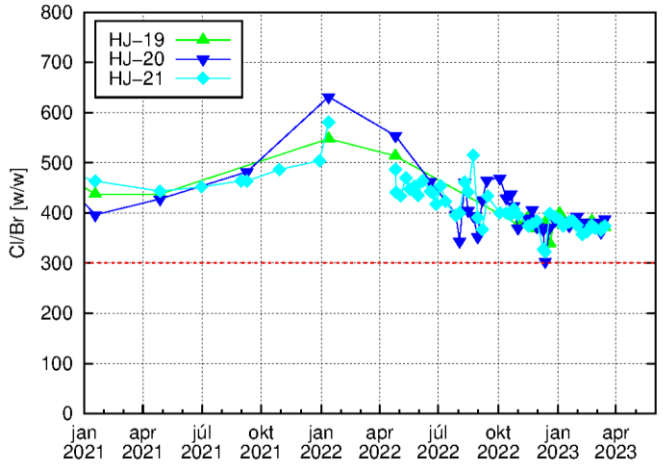
Fluid chemistry:

Brómíð

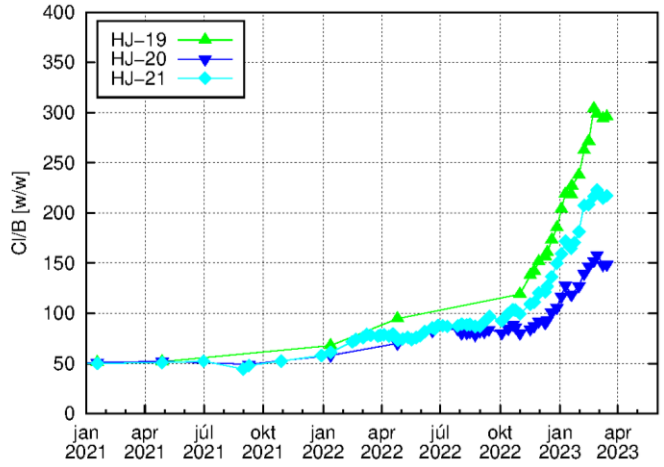


Súlfat





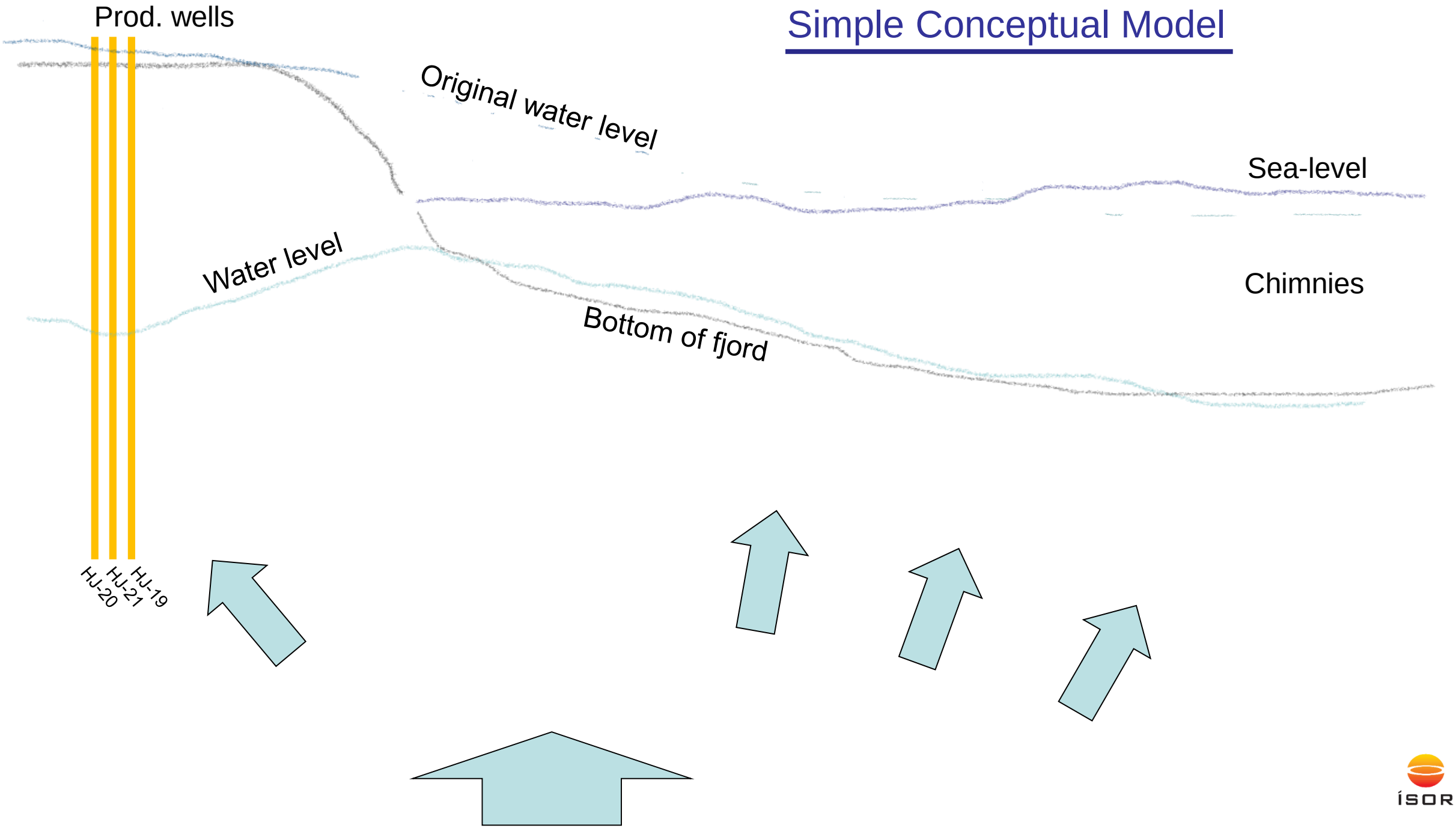
Cl/Br

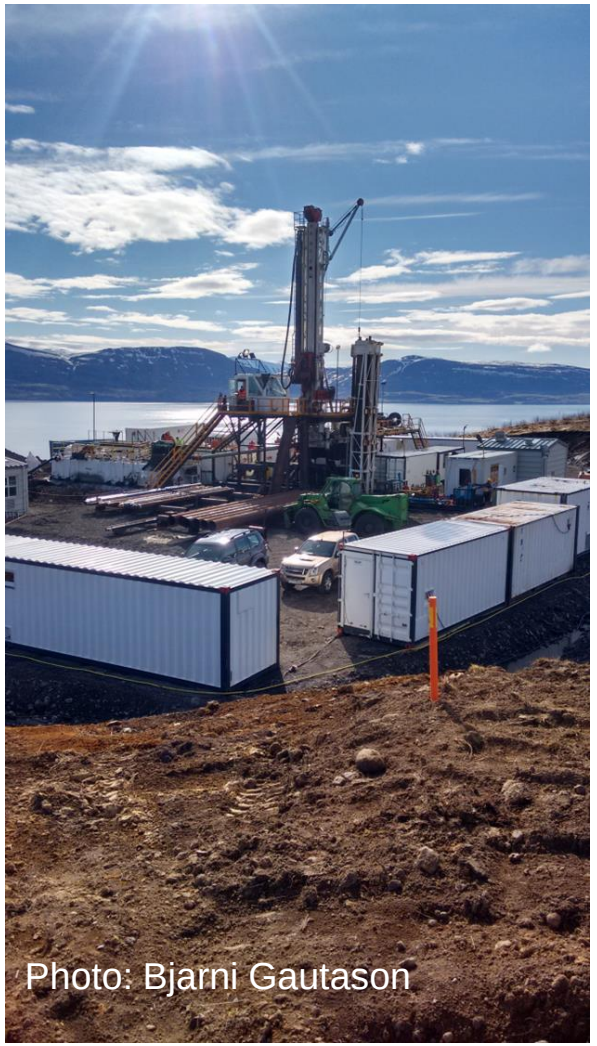


Cl/B

ÍSOR

Simple Conceptual Model





Thank you!

ÍSOR