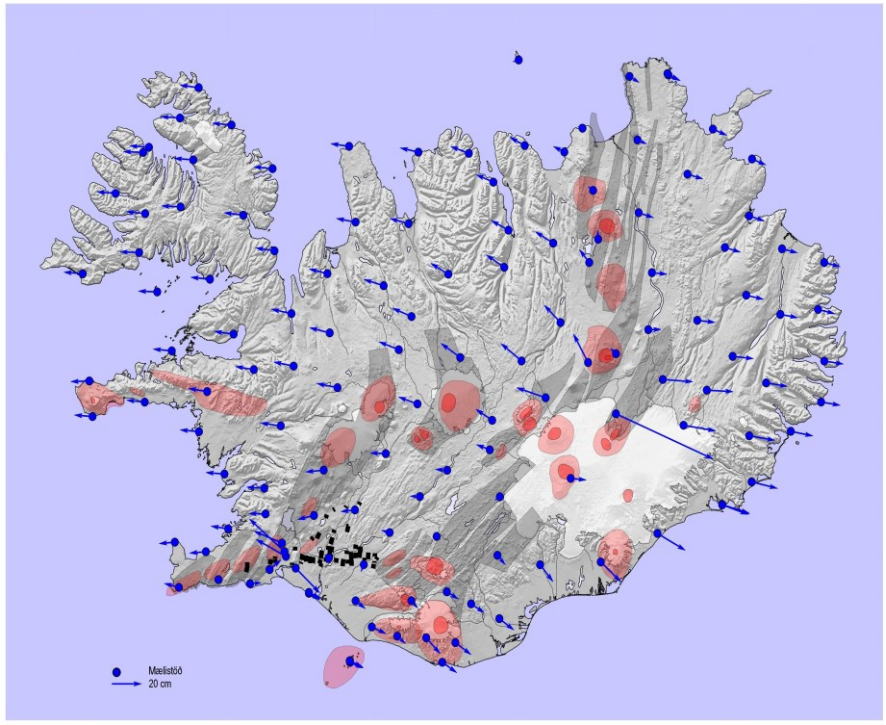
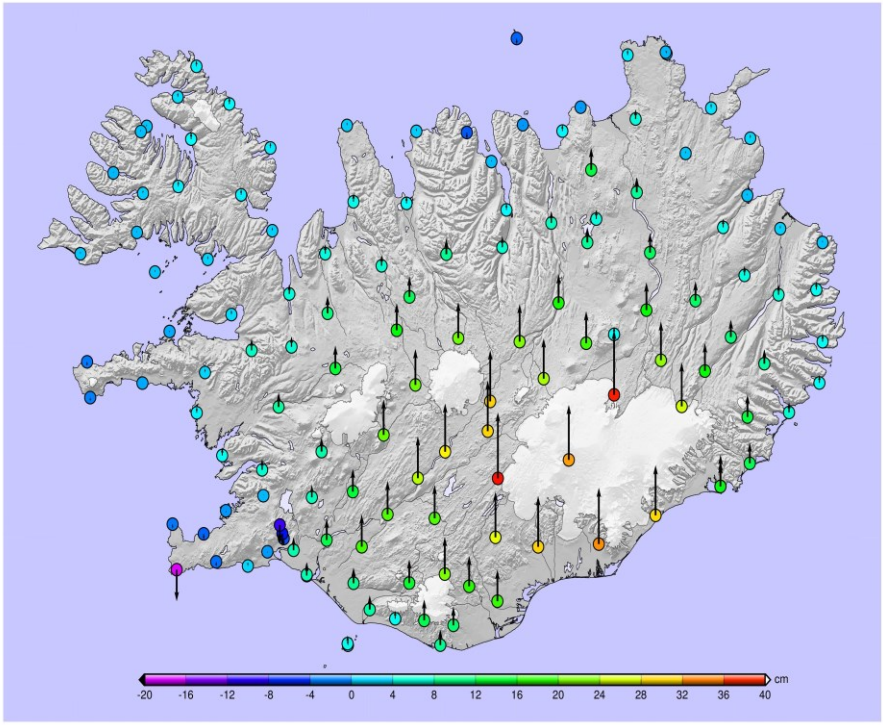
Dynamic Reference Frames in Iceland





Halfdan Pascal Kierulf et al.

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Background

- Scenario: Smartphones give positions within dm or cm accuracy
  - in real time
  - in a global and dynamic reference frame
- Australia has decided to implement a fully dynamic reference frame in 2020.
- Is a static “plate fixed” reference frame the best solution for the users in the future?
- A controversial topic causing at lot of discussions

Project mandate from presidium in the Nordic Commission of geodesy:

The outcome of this pre study should be a project proposal for implementation of a dynamic reference frame (DRF) in Iceland. The proposal must highlight how to implement the DRF, the costs involved, resources needed, scope, quality level and time needed.

Conditions to be excluded from the pre study:

Legal consequences and possible change of legislation

Deliverables and Milestones

Main deliverables:
HL1: First drafted project proposal for presentation to the Director Generals.
First draft shall contain indications of expected costs involved in the implementation phase.
HL2: Second drafted project proposal prepared for review
HL3: Final project proposal for presentation to the Director Generals
HL4: Short report that describes recommended way forward

Milestone and deadlines:
MP1: Project group in place and mandate accepted by both the steering committee and the project group, 2017/01
MP2: First draft finalized and presented to Director Generals at “lille sjefsmøtet”, 2017/05
MP3: Second draft finalized and prepared for review, 2017/06
MP4: Final delivery finalized and presented to Director Generals at « stora sjefsmøtet», 2017/08
MP5: NKG presidium closes the pre study and discusses the way forward 2017/09

Project group:

- Halfdan Pascal Kierulf, Project leader
- Gudmundur Valsson, Iceland, RF, local expertise
- Ásta Krístín Óladóttir, Iceland, GIS
- Hafliði Magnússon, Iceland, IT
- Dalia Prizginiene, Iceland, RF
- Martin Lidberg, Sweden, RF
- Per Knudsen, Denmark, RF
- Kristian Evers, Denmark, GIS
- Markku Poutanen, Finland, RF
- Teemu Saloriutta, Finland, GIS
- Pasi Häkli, Finland, RF
- Olav Vestøl, Norway, RF

- Per Erik Opseth, Norway, Project owner
- NKG Presidium, Steering comittee

Meeting in Akranes Feb. 22-23

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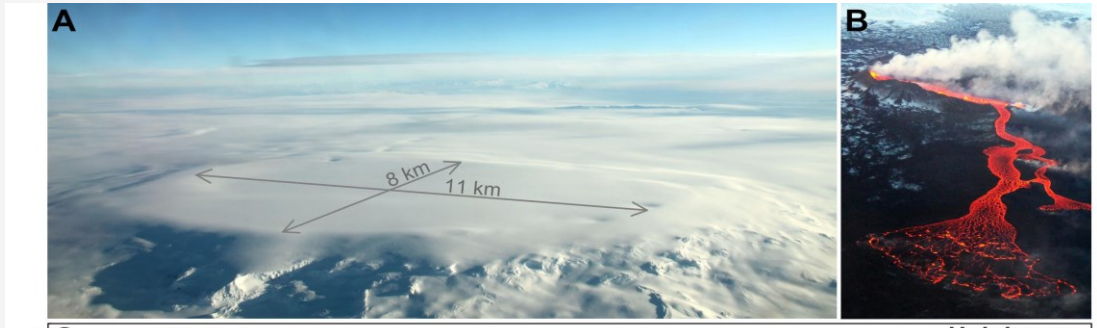
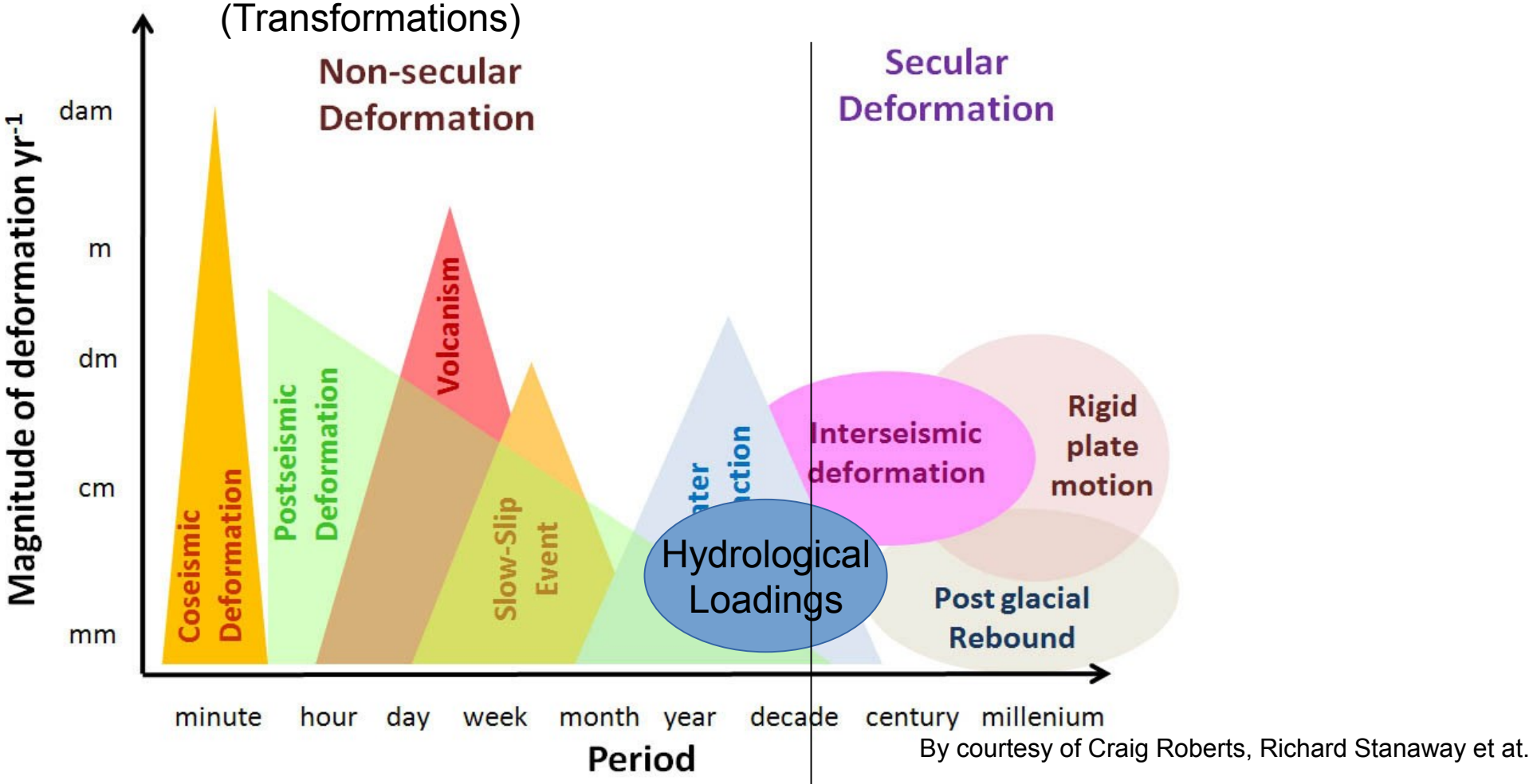
In Iceland the deformations are much more complex

-Two plates are drifting apart ~2-3 cm/year
-Deformations within the plates
-Earthquakes ~50 cm
-Volcanoes
-Melting graciers ~40 mm land uplift annually
~more than 10 mm/yr horizontally
-Geothermal power plants - subsidence



We need a way to handle crustal deformation!
(Transformations)



By courtesy of Craig Roberts, Richard Stanaway et at.

Deformaiton model
Patches or ...

Velocity field

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Definitions

-***Passive network:*** consisting of ground markers
-***Active network:*** consisting of Continuously Operating GNSS Reference Stations (CORS)

-***Static RF*** ***(Plate fixed, Epoch fixed):***

The RF moves with the tectonic plate.
The coordinates do not change with time.
Deforming crust causing constraints in the frame and the accuracy decrease.

-***Dynamic RF*** ***(Kinematic, Earth fixed, NNR fixed, Global, 4D)***

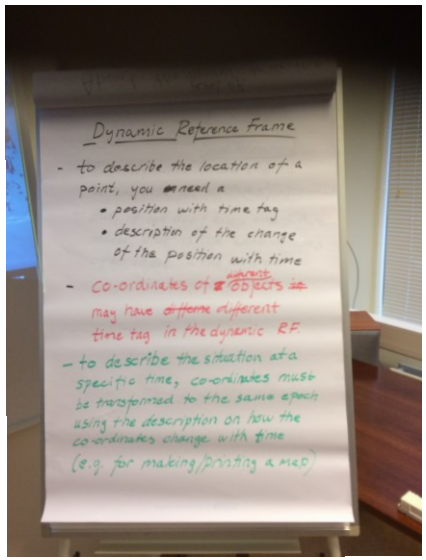
The coordinates have four dimensions x, y, z and t
The RF does not move with the tectonic plates.
The spatial part of the coordinates changes with time.

-***Semi-dynamic RF:***

Any possible combination of static and dynamic thinking.

1. Coordinates have a time evolution but it is applied episodically (ISO19111)
2. A realization of a dynamic reference frame at (a) specified epoch(s) in time
3. A dynamic RF for measurement, and a static RF for map databases

Definitions: Dynamic Reference Frame



GNSS systems provides positions x,y,z within a global reference-frame (ITRF or WGS) at the epoch of the measurement !

↓

A point (x,y,z,t) is:

-uniquely defined

and

- is given directly in the global reference frame
- does not change over time. (But the spatial part will be different at another epoch.)
- deformation models have to be used to present the coordinates at a specific epoch

NOTE:
Because of the time tagging you can:

- store coordinates in your database even though your deformation model is not updated (e.g. after a large earthquake)
- Can always use the latest and most precise deformation model

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How to determine a position in a dynamic reference frame

Examples:

-PPP: direct determination in the DRF

-DD: determination through the ITRF coordinates of your reference stations

-RTK: direct determination if the RTK-GNSS stations are continuously updated in ITRF

-Positioning relative a local marker also works, but the time stamp will be the same as for the local markers.

i.e. all techniques determine positions in the same reference frame without transformations.

Iceland is introducing a new semi-dynamic reference frame ISN2016.

ISN2016 will be a good starting point for a Dynamical Reference Frame on Iceland

New semi-dynamic datum for Iceland ISN2016

- We intend to release a new semi-dynamic datum ISN2016
- Similar to the GDNZ2000, but we will also take the vertical component into account
- Just started working on the secular deformation model
- The difference between ISN2004 and ISN2016 can be used as basis for the model
- But there are some challenges and some more data to be considered

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GIS challenges

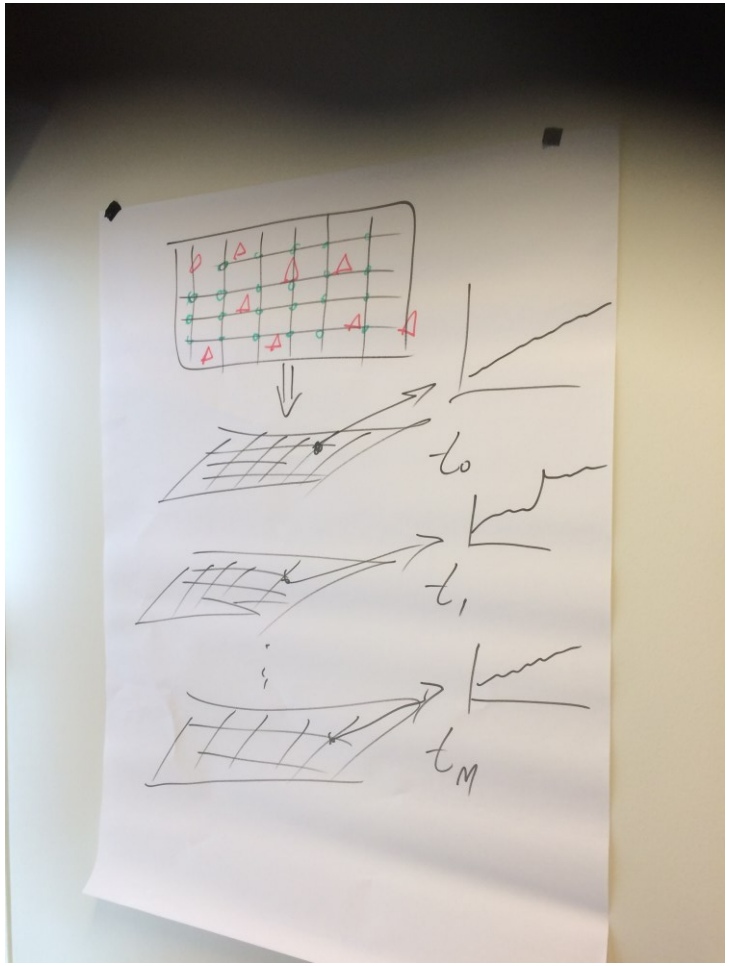
Key question: How should the time dimension be handled in GIS!

- What we already have:
  - Satisfactory standards for describing metadata of geospatial exists
  - File formats that can accommodate the required spatiotemporal coordinates
  - A coordinate transformation platform with widespread usage that can be extended into the realm of dynamic reference frames: PROJ.4

- What we are missing:
  - Widespread adaptation of the most recent metadata standards (WKT2)
  - Usage of the new PROJ.4 API in geospatial software
  - Extended geodetic capabilities in PROJ.4
  - 14 param. shifts, temporal awareness, etc
  - A different user mindset

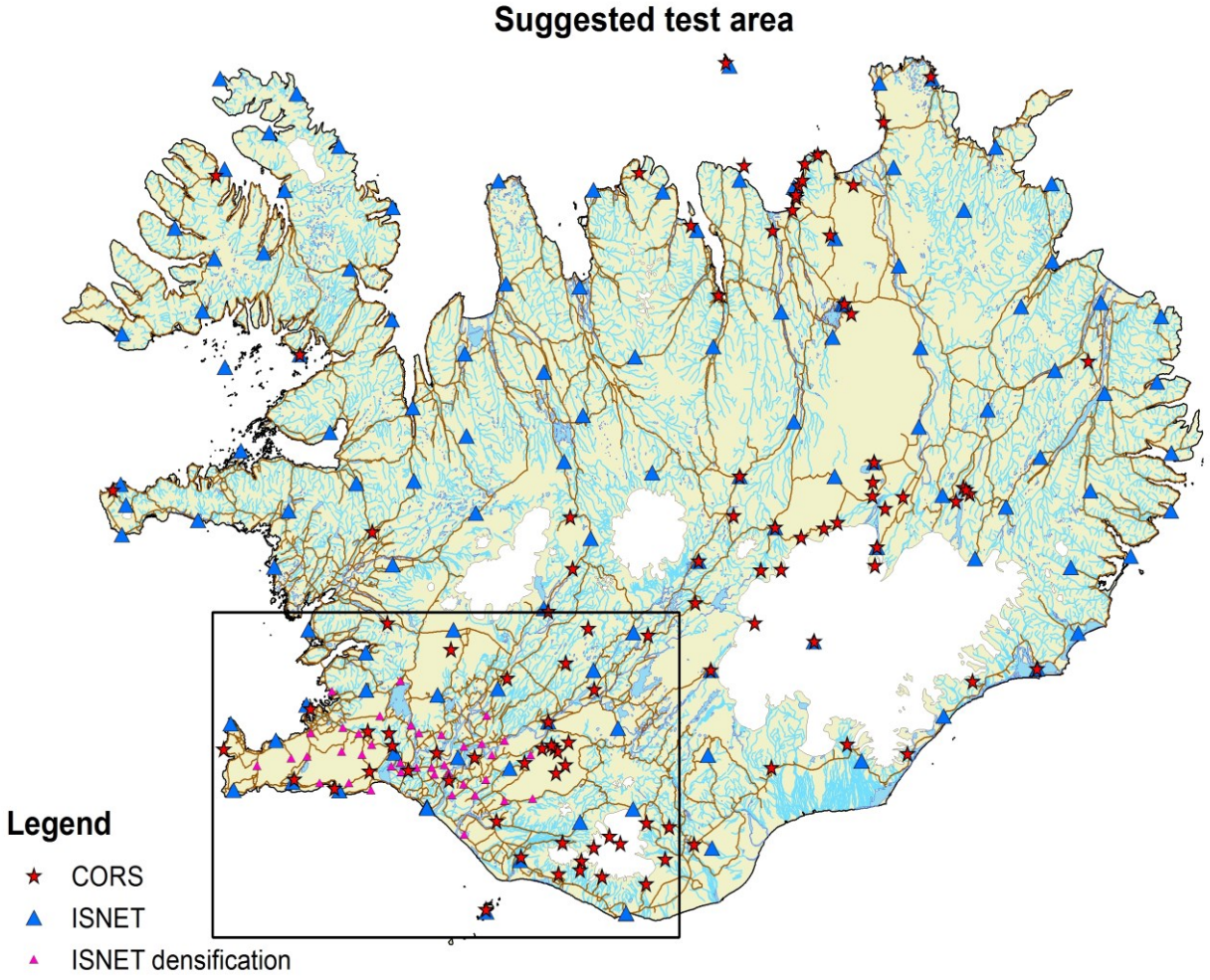
- Updating map databases:
  - How will web services (WMS, WFS, etc) work in a dynamic reference frame? Often huge amounts of data which is not feasible to transform on the fly. Should it be transformed and updated to “current epoch” with regular intervals? How often? Every week, month or year?

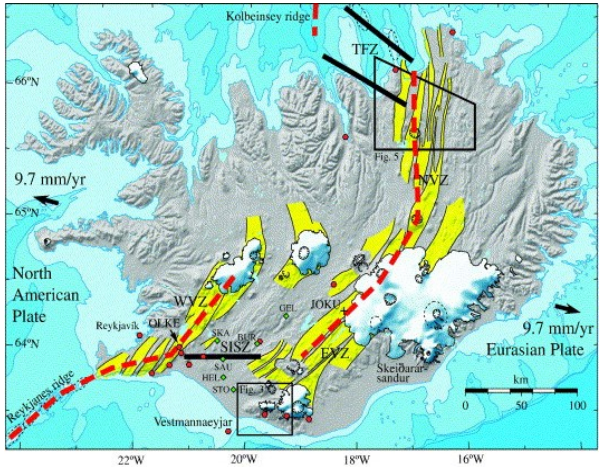
After discussions between the project, the owner and the NKG-presidum it was decided to narrow the project focus:



- Focus on the deformation models in a test area
- Postpone the implementation in GIS
- Exclude the necessary GNSS infrastructure development from the project

Recognition:
Whatever type of reference frames you have, the knowledge of crustal deformation is needed.





The test area has:

-Sufficient GNSS infrastructure

-Large deformations from:

- Two continental plates
- Deformation zone
- Earth quakes
- Volcanoes
- Uplift from glacial melting
- Subsidence due to power plants

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Thank you!