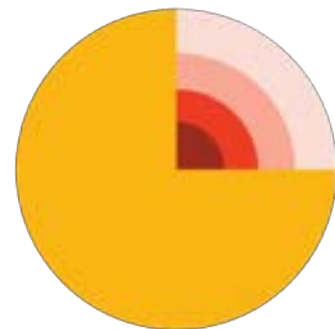


Icelandic Meteorological Office in ChEESE-2P



Icelandic Met Office

Benedikt Halldorsson, Tómas Jóhannesson & Sara Barsotti
Icelandic Meteorological Office (VEDURSTOFA ISLANDS – “IMO”)
Reykjavik, Iceland



ChEESE

ChEESE-2P Kickoff Meeting – Barcelona – 19-20 Jan. 2023

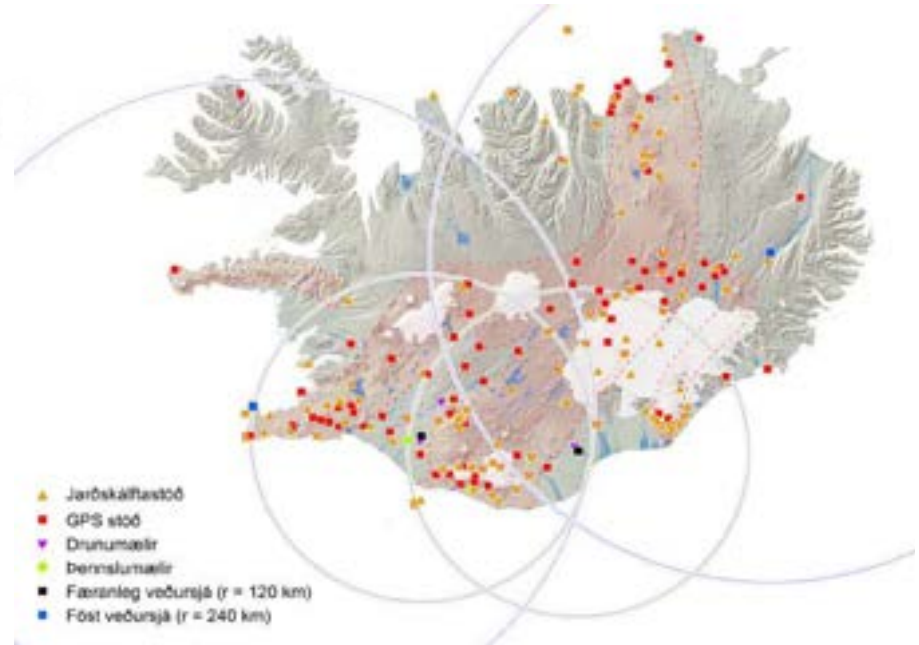


Project funded by EuroHPC under the grant agreement No 101093038.

Icelandic Meteorological Office

- Official research and monitoring agency of natural hazards
- Geohazards monitoring
 - Seismicity
 - Volcanic tephra
 - GPS deformation
 - Remote sensing
 - Gas emissions
 - Radar and ultrasound
- Water monitoring
 - Flooding
 - Thawing
 - Glacier conditions
- Climate and Weather monitoring

The Icelandic Met Office deals with natural multi-hazards affecting Icelandic society



ChEESE-2P IMO's participation - overview

- Participates in 4 WPs
 - WP1 Project management
 - WP7 Results dissemination, outreach and capacity
 - **WP5 Pilot Demonstrators**
 - **WP6 Simulation Cases and Service Enabling**
- Type of activity
 - Communication, dissemination, engagement
 - **Co-definitiaon of research and market needs**
 - **Research performer**
 - **Testing/validation of approaches and ideas**
 - Prototyping and demonstration

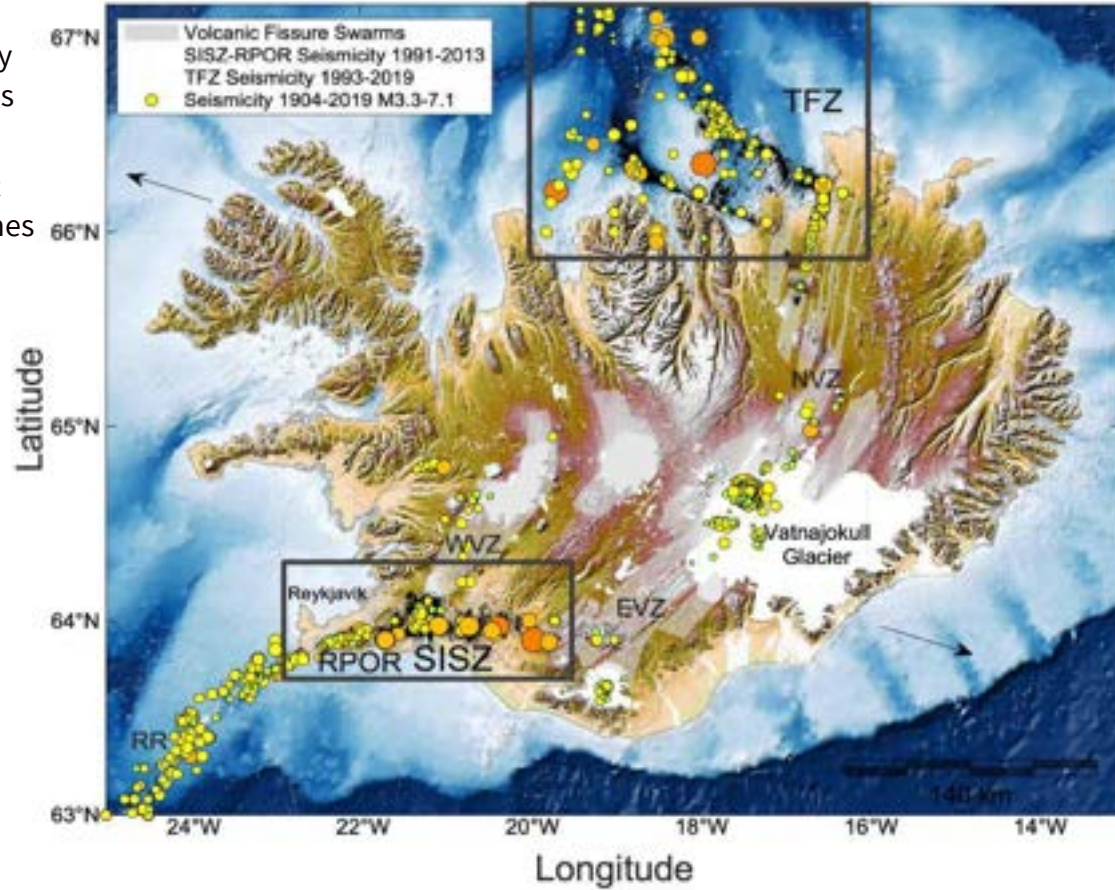
- Simulation Cases
 - SC1.2 Next generation of earthquake simulators for the Hellenic arc and Iceland
 - **SC1.3 Physics-based PSHA and urgent UQ for Iceland: next generation hazard map**
 - SC5.1 Towards the European tephra hazard model
 - **SC9.1 Eastern Skaftá cauldron Glacier Outburst Floods (GLOF) simulation, Iceland (lead)**
- Participation type
 - Basic research (seismic cycles)
 - Hazard assessment (seismic, tephra, glacial outburst floods)
 - Urgent computing (seismic hazard, uncertainty)

WP	WP1	WP2	WP3	WP4	WP5	WP6	WP7	Total
IMO PMs	2	/	/	/	24	18	2	46



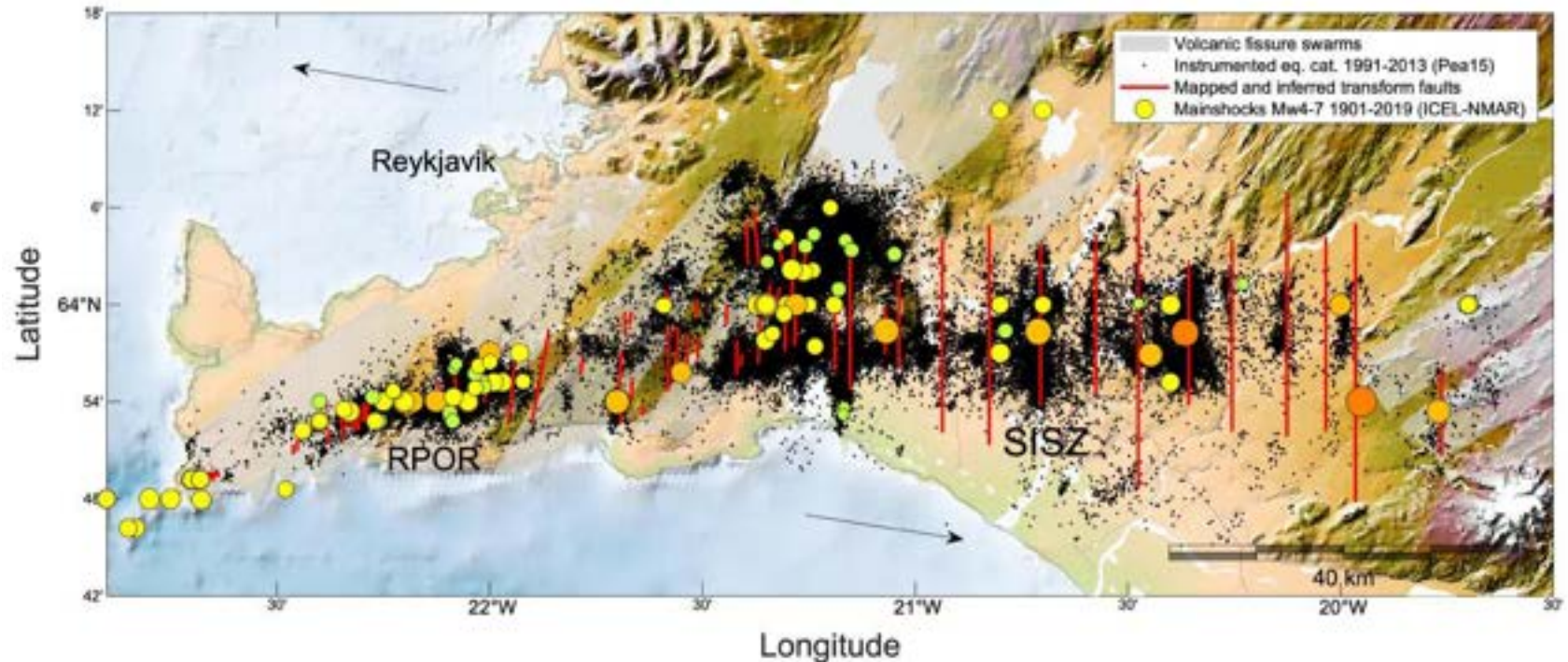
The volcano-seismotectonics of Iceland

- The Mid-Atlantic Ridge extensional plate boundary goes through Iceland and forms the volcanic zones
- A gradual eastward ridge-jump of the Mid-Atlantic Ridge on land has formed two large transform zones
 - South Iceland Seismic Zone (SISZ) and Reykjanes Peninsula Oblique Rift
 - Tjörnes Fracture Zone (TFZ)
- The largest earthquakes, up to $M_w 7.2$, in Iceland occur in the transform zones
- The largest strike-slip fault in the country, the Húsavík-Flatey Fault Zone, is in the TFZ
- Both the SISZ-RPOR and a part of the TFZ fault systems are characterized by bookshelf faulting



South Iceland Seismic Zone (SISZ) and the Reykjanes Peninsula Oblique Rift (RPOR) (SC1.2, LMU, TUM, CNRS, UM, IMO)

- A **long E-W** transform zone characterized by **short N-S** strike-slip faults ("bookshelf") that dominates the tectonic strain release in between volcanic episodes



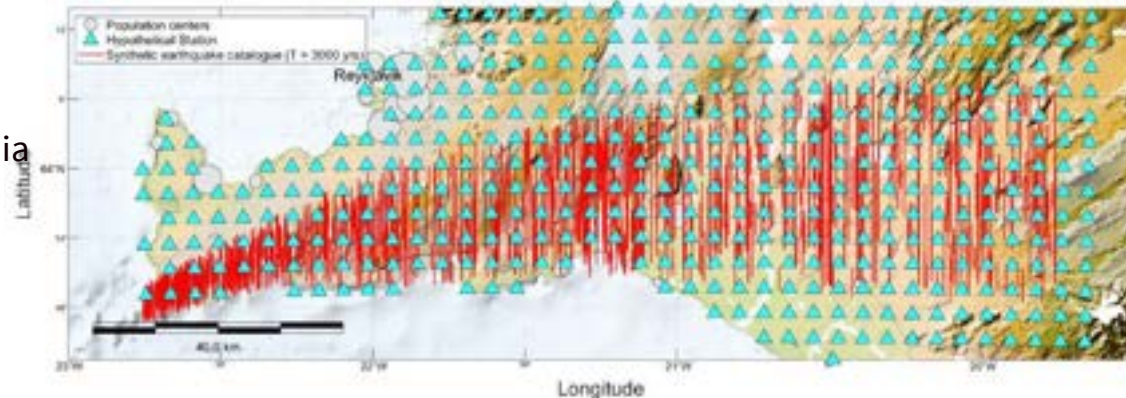
Physics-based PSHA in Southwest Iceland (SC1.3, LMU, IMO, BSC, TUM)

- Builds on ChEESE results

- New** physics-based 3D earthquake source model for both SISZ-RPOR & TFZ
- New** earthquake scaling relationships for the SISZ
- New** dynamic & kinematic rupture modeling, ground motion and tsunami simulations on the largest strike-slip fault in Iceland
- BSC's initiative** of securing the first application of SCEC's **CyberShake** earthquake simulator outside California
→ SISZ-RPOR fault system

- CyberShake ~6 million event-station pairs of synthetic seismic ground motion time histories
- Resolving the complex long-period near-fault effects
- Physics-based near-fault PSHA and uncertainty quantification

A single realization of a 3000 year finite-fault catalogue and dense hypothetical station grid.

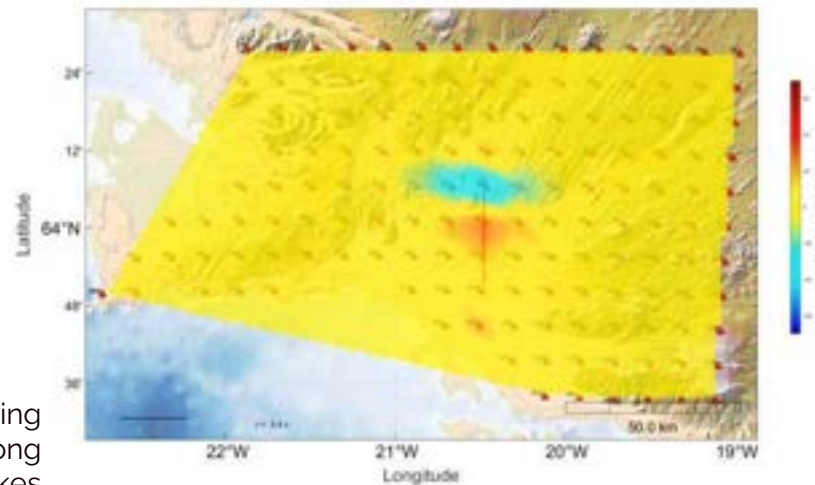


Physics-based PSHA in Southwest Iceland (SC1.3)

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Near-fault velocity pulses are the most damaging feature of seismic waves in the vicinity of strong earthquakes

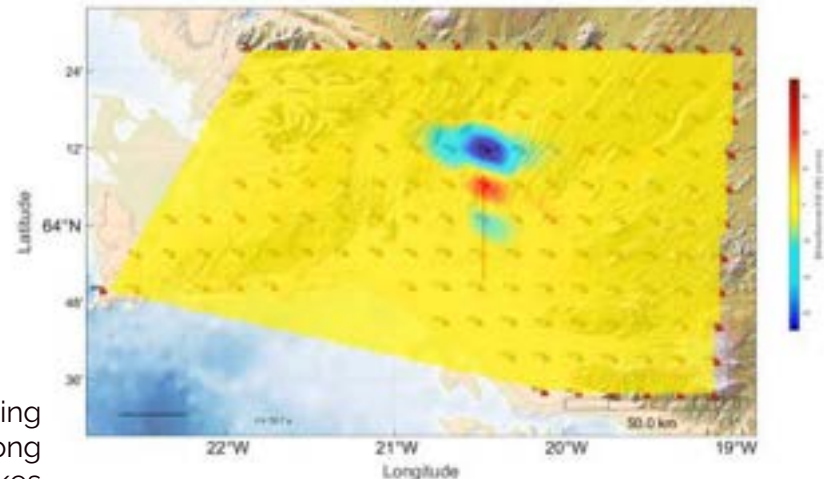


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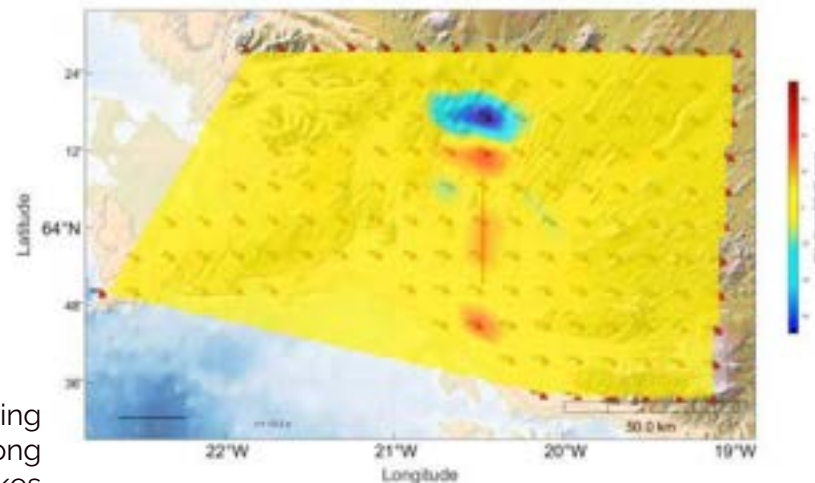


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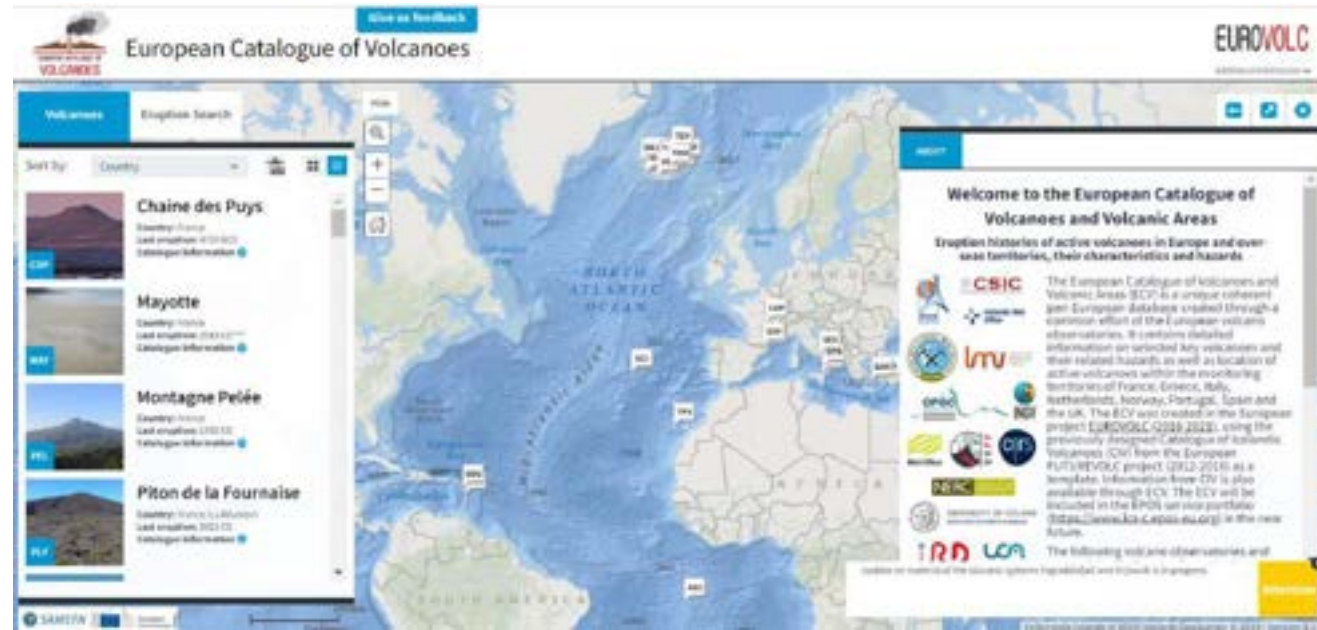


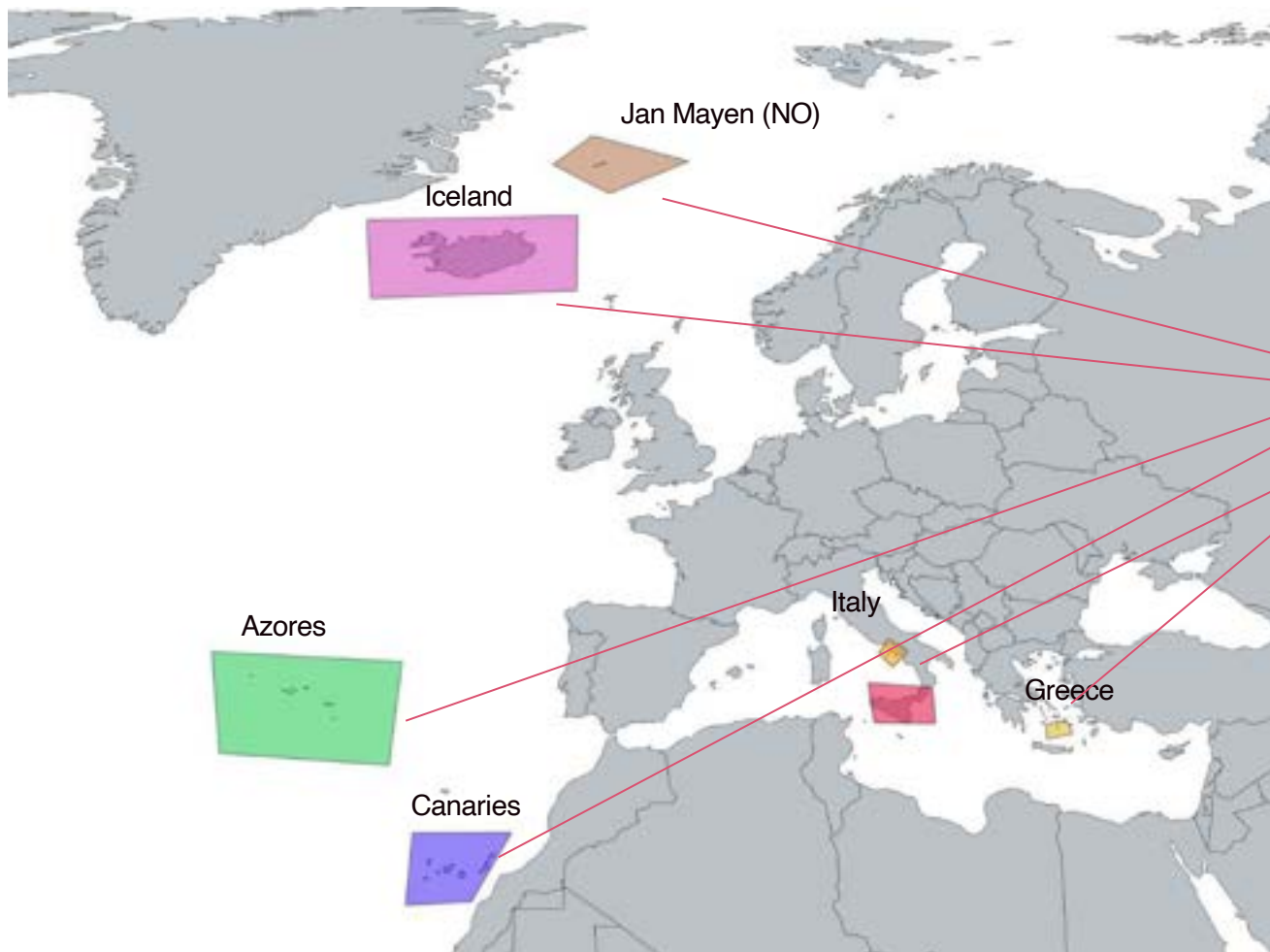
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PD5 Ensemble-based volcanic dispersal across multiple scales (SC5.1, **CSIC**, INGV, IMO)

- The European Catalogue of volcanoes is one of the main final products of the EUROVOLC EU H2020 Project run at IMO
- It provides an overview of eruption scenarios for several volcanoes in Europe: <https://volcanoes.eurovolc.eu/>





In ChEESE-2P

- Eruptive scenarios will be identified for a subset of volcanoes to be simulated



First tephra hazard map at European scale



Glacial Outburst Floods (GLOF, *jökulhlaup*) (SC9.1, **CNC**, CNRS, IMO)

Eastern Skaftá Cauldron in Vatnajökull Glacier,
after a *jökulhlaup* in September 2021



Photo: RAX
9 September
2021



22 April 2006
Oddur Sigurðsson

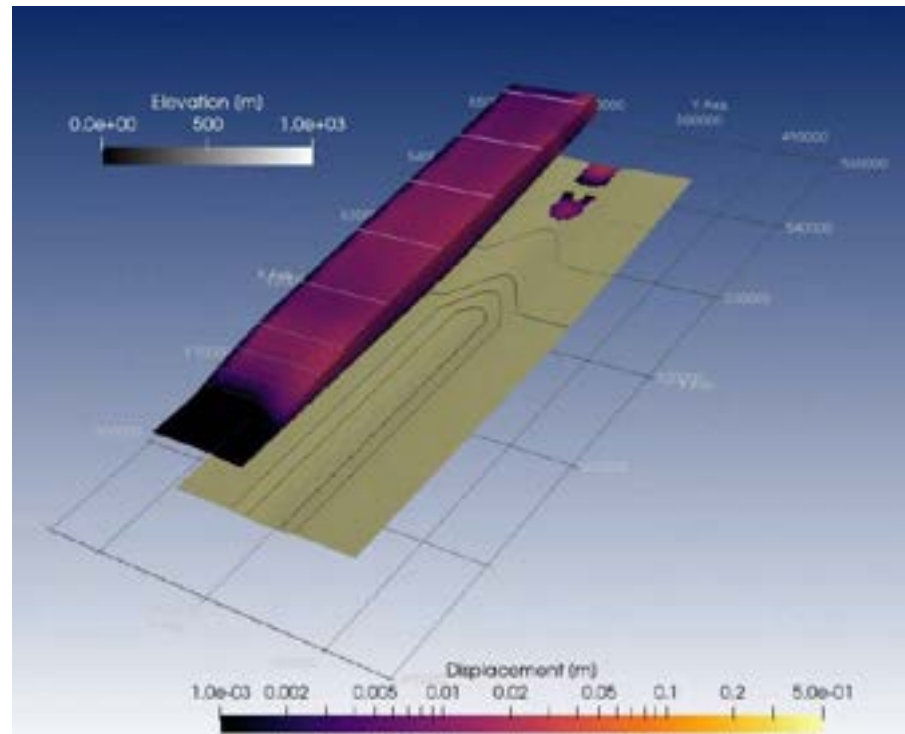
 Icelandic Met Office



ChEES-2

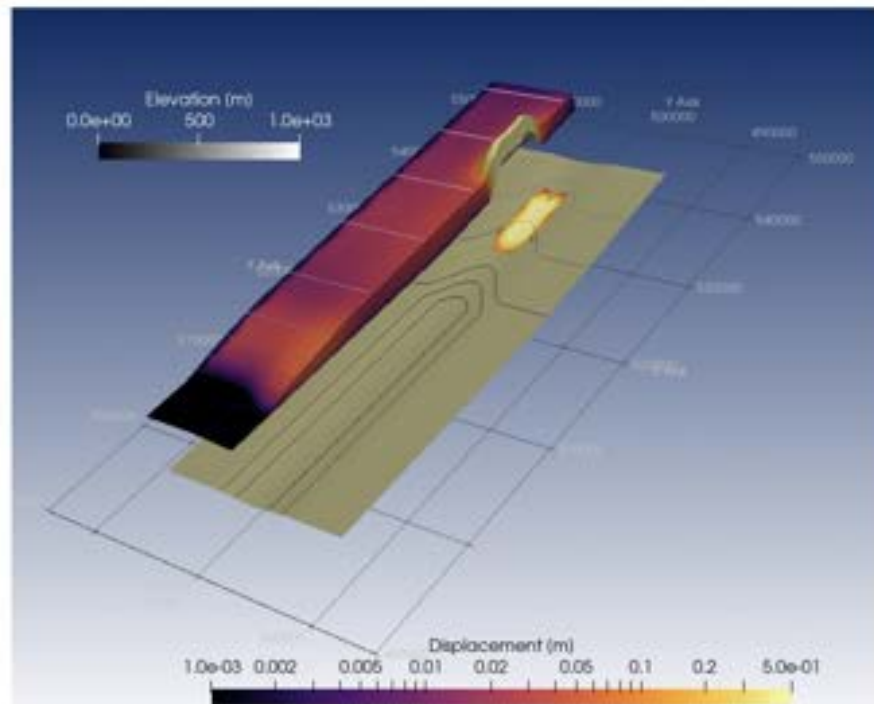
Results of GLOF visco-elastic model

- The overall dimensions are based on the geometry of Skaftárjökull outlet glacier and the flood path of jökulhlaups in river Skaftá
 - A 50-m deep, smooth depression in the bottom topography represents a subglacial valley along which the flood travels.
 - The pressure disturbance is ~3000 m long and ~2000 m wide, with a +200 kPa (over-)pressure near the tip that decreases linearly to a -50 kPa (under-)pressure with respect to overburden at the back, extending upstream as far as the pressure bulge has travelled.



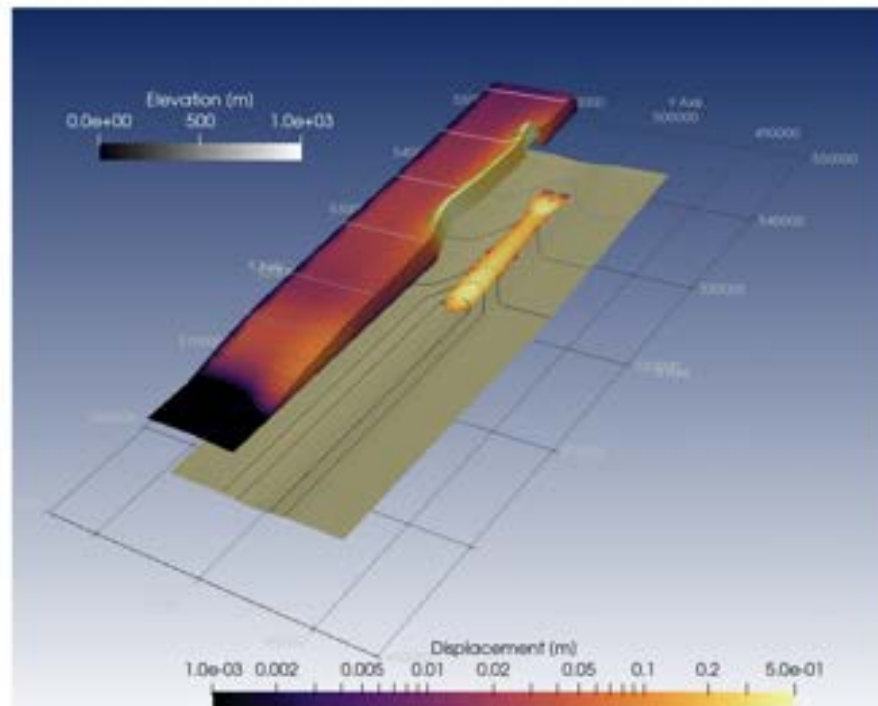
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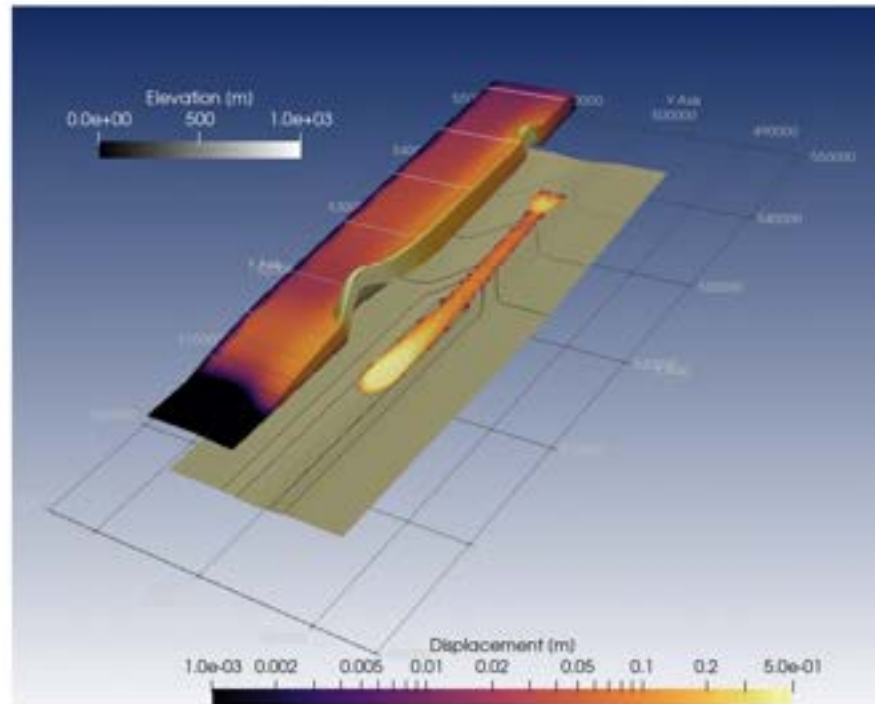
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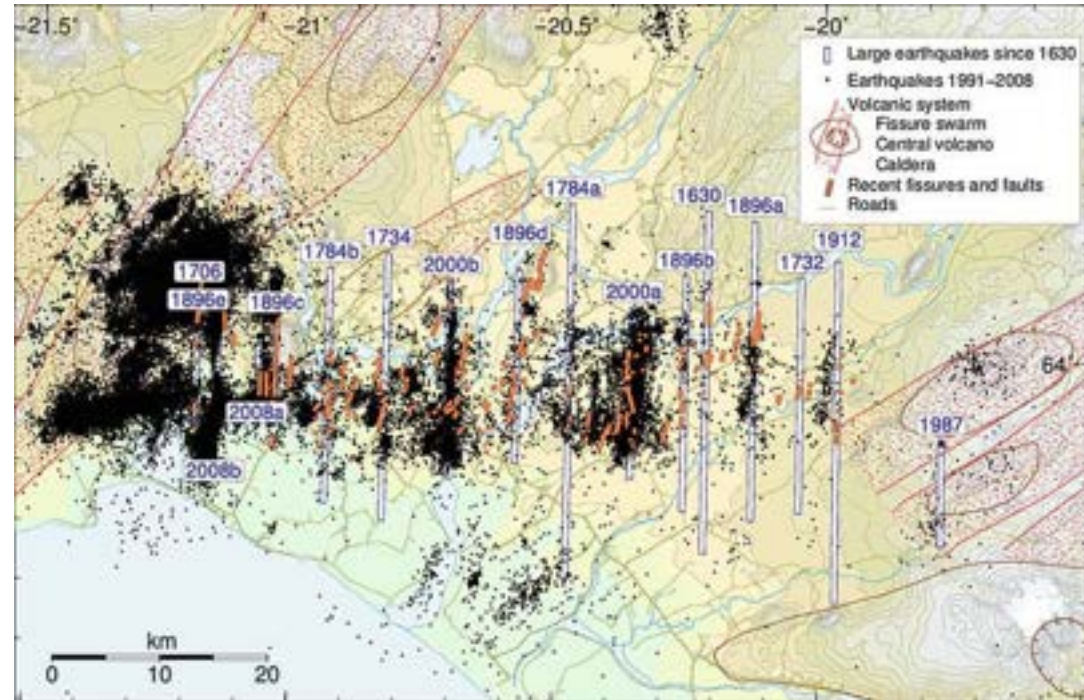




**Thank you, and looking forward to
our collaboration**

Modeling the detailed spatiotemporal nature of the SISZ seismic cycle (SC1.2)

- Drivers of SISZ eq. activity
 - Tectonic transform motion across SISZ
 - Intense rifting episodes in the volcanic zones
- Strong-earthquake activity is characterized by
 - Large single eqs. in the eastern SISZ
 - Sequences of moderate-to-strong earthquakes all over the SISZ
 - Earthquake triggering along the SISZ-RPOR
- Seismic cycle ~100-150 years
 - From historical records



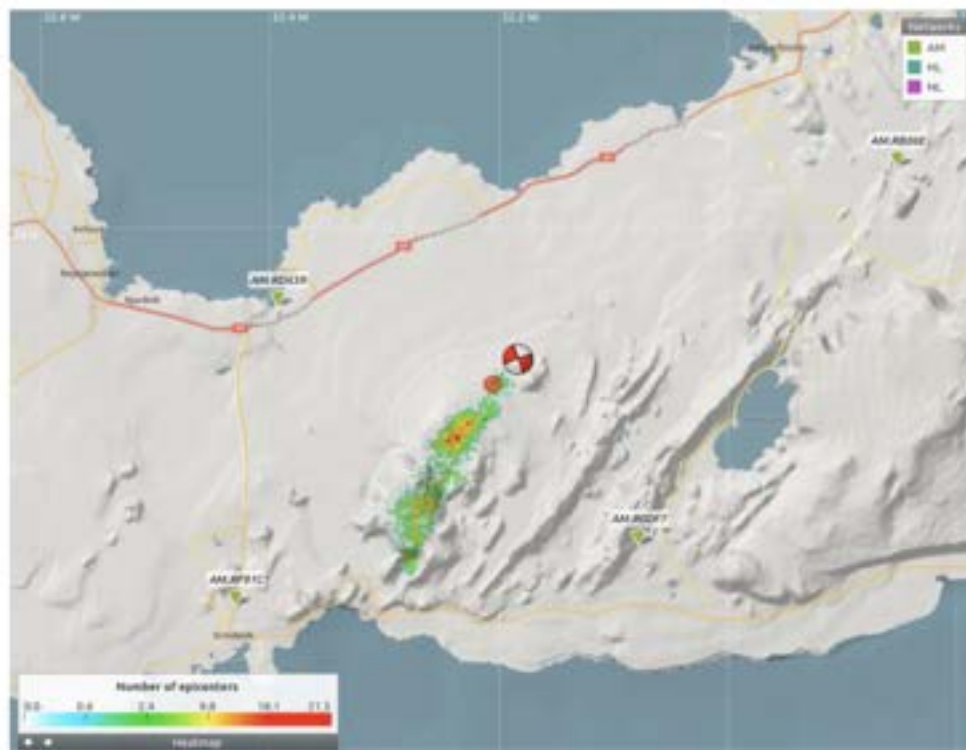
SISZ "Bookshelf tectonics" over the last ~300 years

(Einarsson, 2014)

Modeling the detailed spatiotemporal nature of the RPOR seismic cycle (SC1.2)

- Has a new volcanic episode just commenced?
- Prelude – Seismic sequence period
 - Dec. 2019 to June 2020: Localized magma intrusions/sills in Western RPOR causing uplift and seismic activity
 - 20 Oct. 2020, a M5.6 strike-slip earthquake occurred on a N-S transform fault in central RPOR
- 24 Feb. 2021 – New seismic sequence
 - Seven M5-5.7 strike-slip eqs. on N-S bookshelf faults in central RPOR
 - Magmatic dike intrusion striking SW-NE
- 19 Mar. 2021 – Fagradalsfjall volcanic eruption
 - In central RPOR, near the SW-end of the dike

24. Feb. – 19. Mar. 2021
Dike intrusion along a SW-NE extensional fault



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Two months seismicity ($M>1$) after 7 $M>5$ earthquakes and start of eruption
Concentrated in lobes at ends of intrusion

