2021-2023 unrest and geodetic observations at Askja volcano, Iceland

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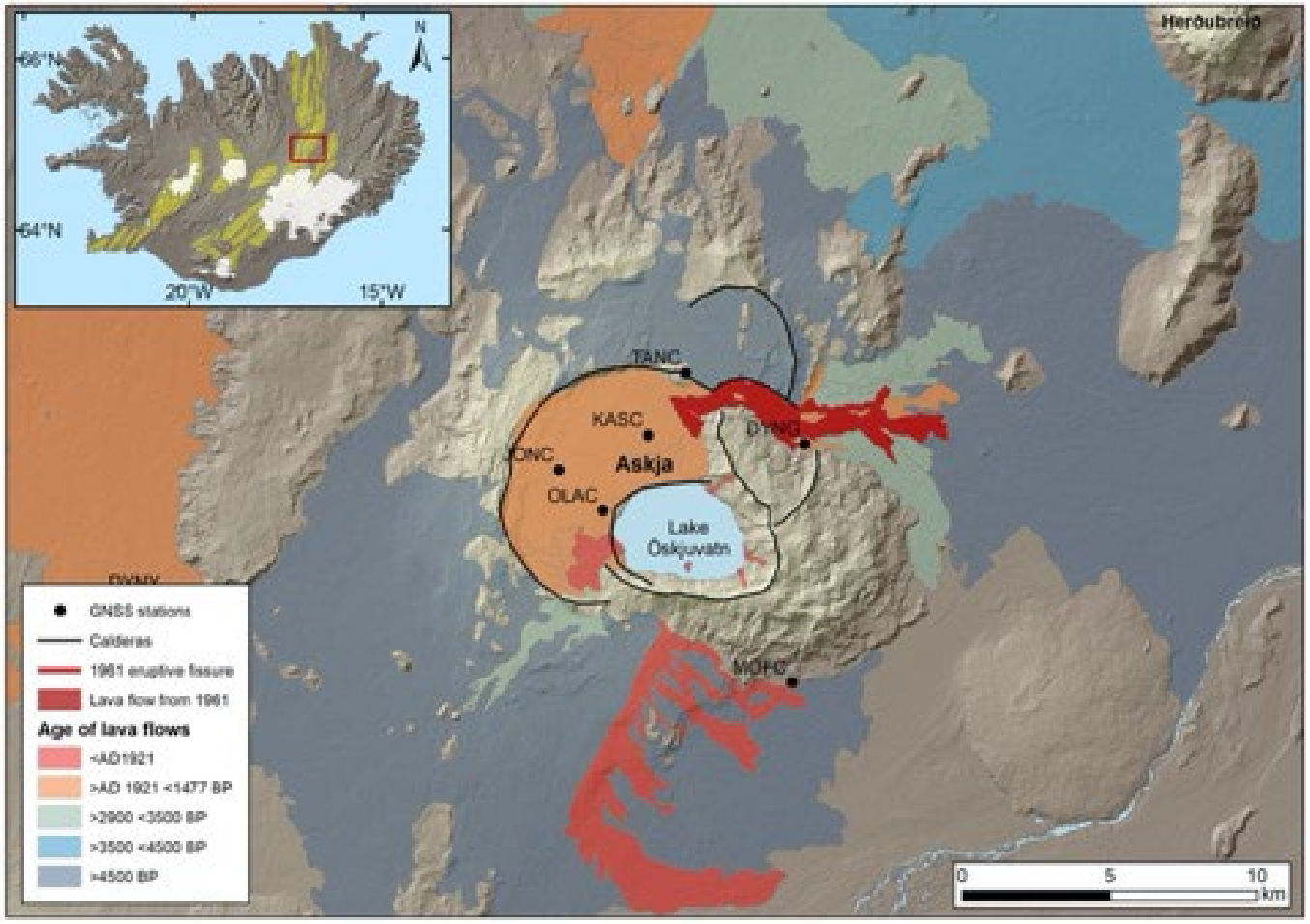
Geological map: Askja volcanic complex



Inflation signal first detected on OLAC at start of August 2021

3 new GNSS stations installed in September-October 2021

OLAC installed in 2015

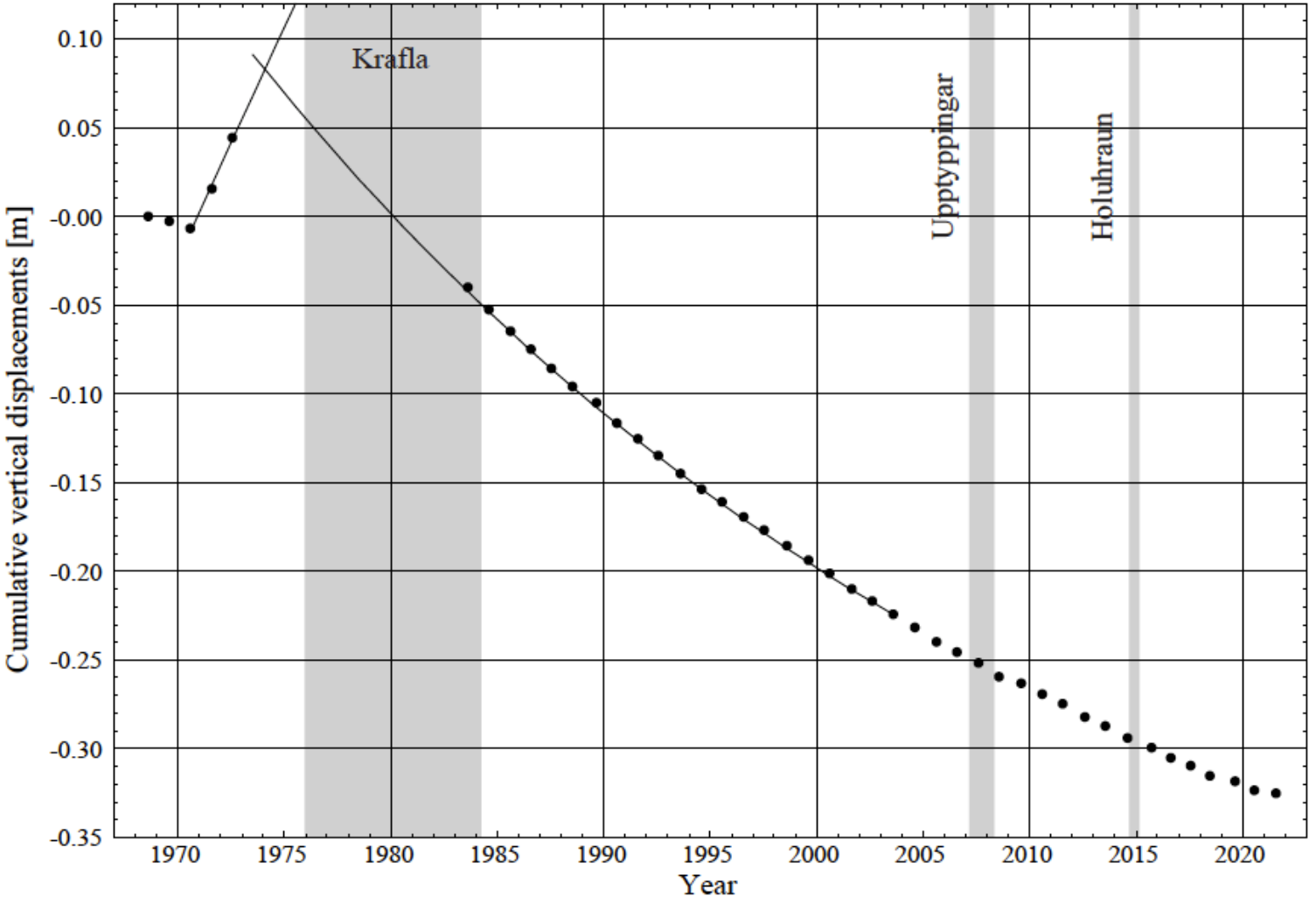
DYNG and MOFC installed in 2014

Mapped lava flows are from Guðmundur Sigvaldason et al., 1992.

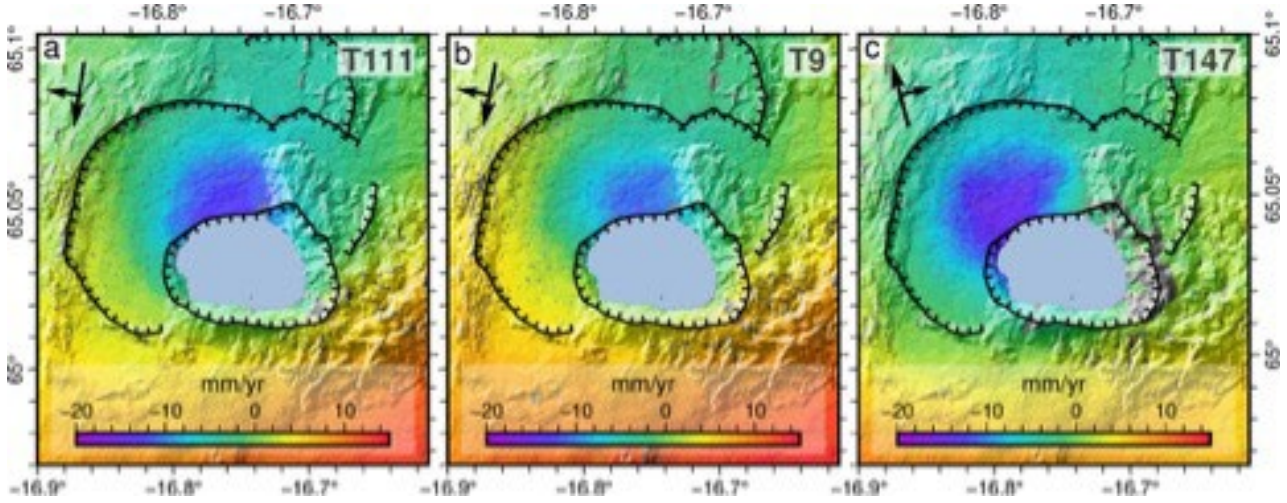
Background

- Eruptive activity comprises both explosive and effusive eruptions
- Composition of eruptive products ranges from basaltic to rhyolitic
- Last eruption at Askja was in 1961
- Most recent caldera formed following the 1875 plinian eruption. This is now filled with lake Öskjuvatn
- Long-term subsidence was occurring at Askja from 1983-2021
- Suggested processes behind this include magma cooling and contraction or outflow
- GNSS observations at OLAC show inflation from end of July 2021 onwards
- Inflation also observed on InSAR analysis and levelling profiles

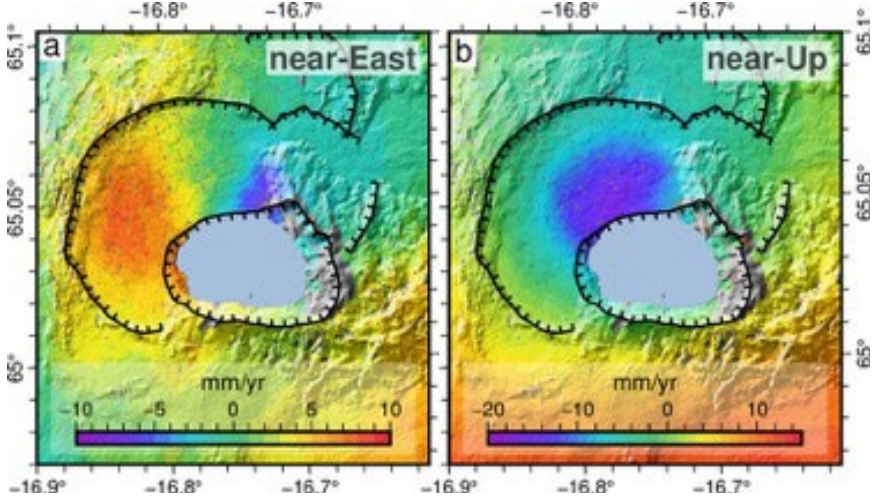
Previous deformation – levelling data from 1968 to 2021



Prior to recent inflation there was long-term subsidence

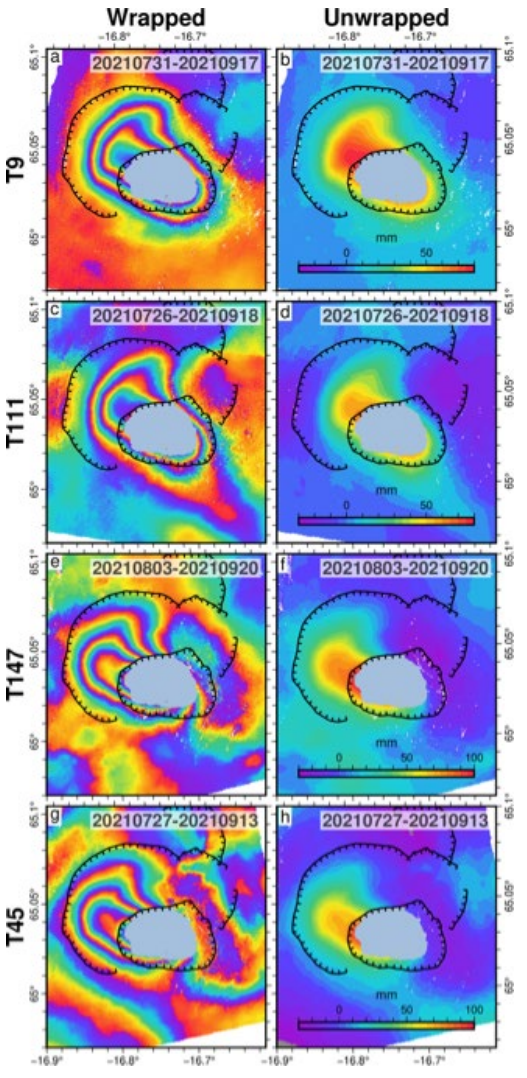


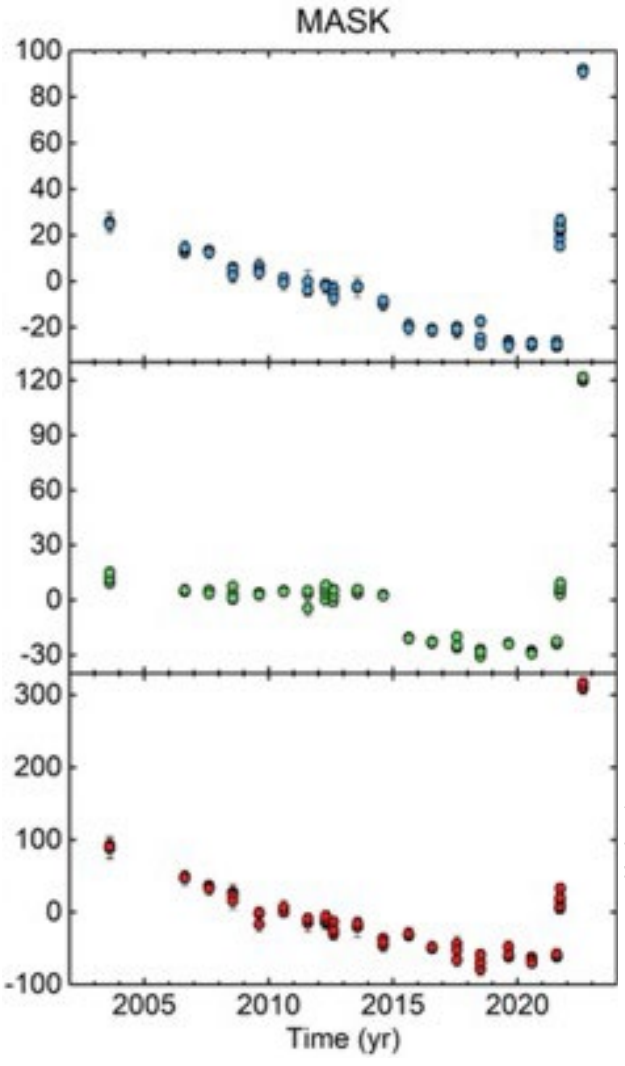
Interferograms at Askja volcano, showing line-of-sight (LOS) displacements, from three separate Sentinel-1 tracks spanning 2015 to 2020.

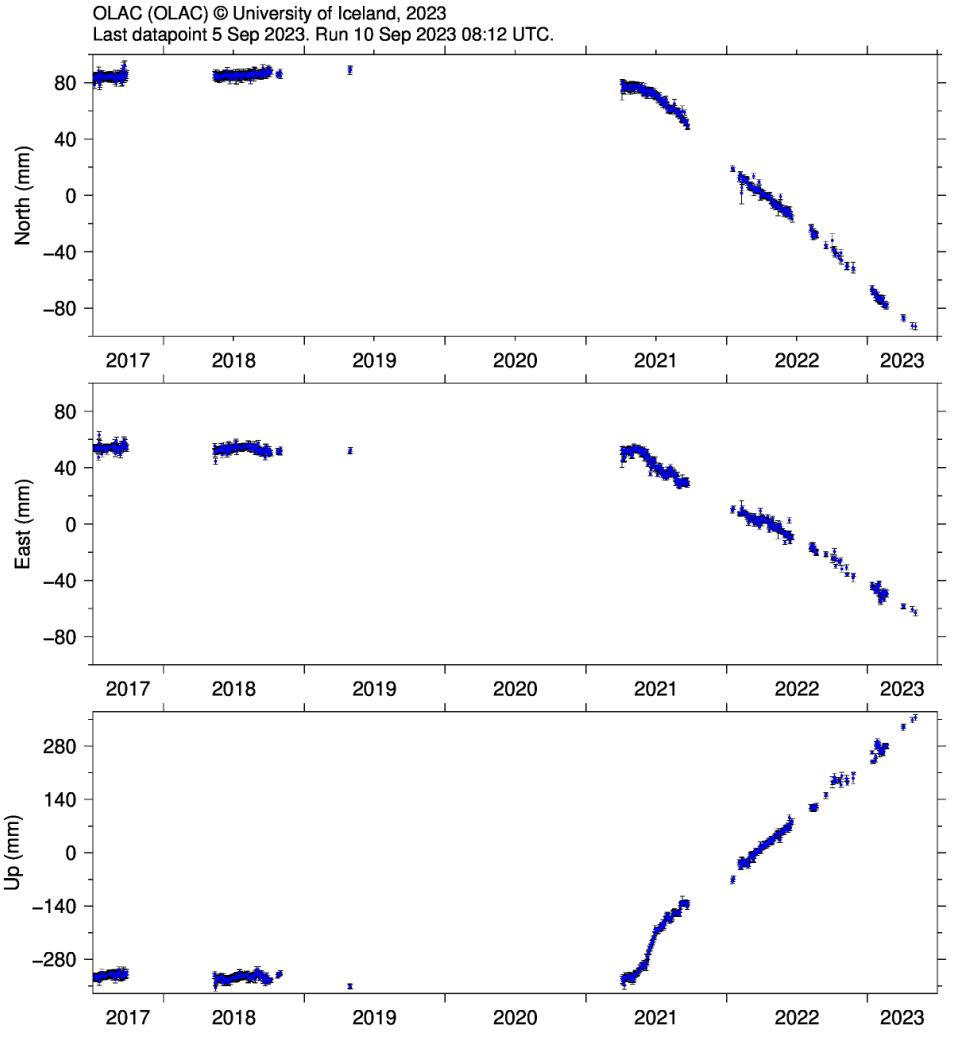


Near-east and near-up displacements derived from Sentinel-1 interferograms displayed above.

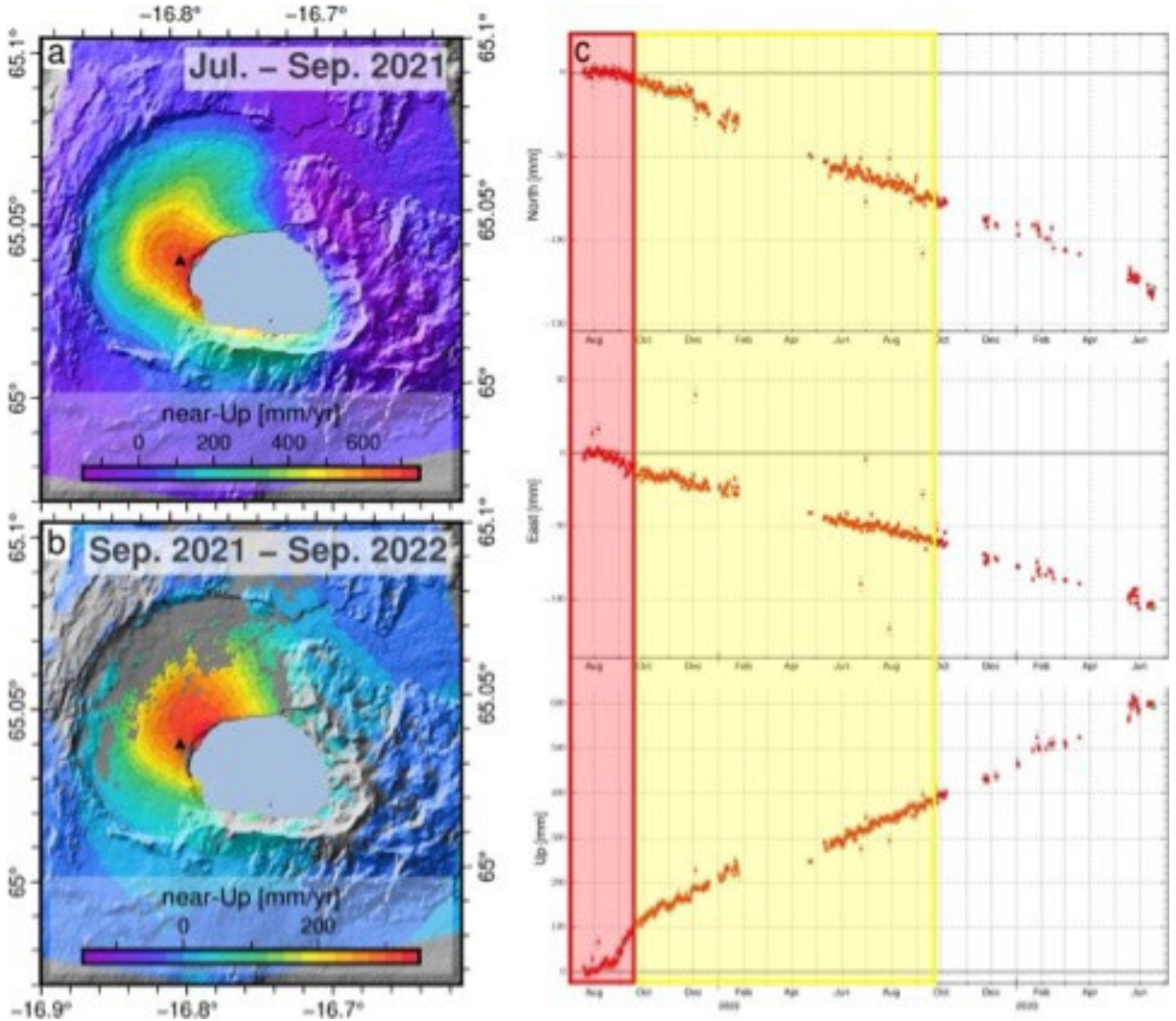
Change to inflation detected during summer of 2021 on both InSAR and GNSS





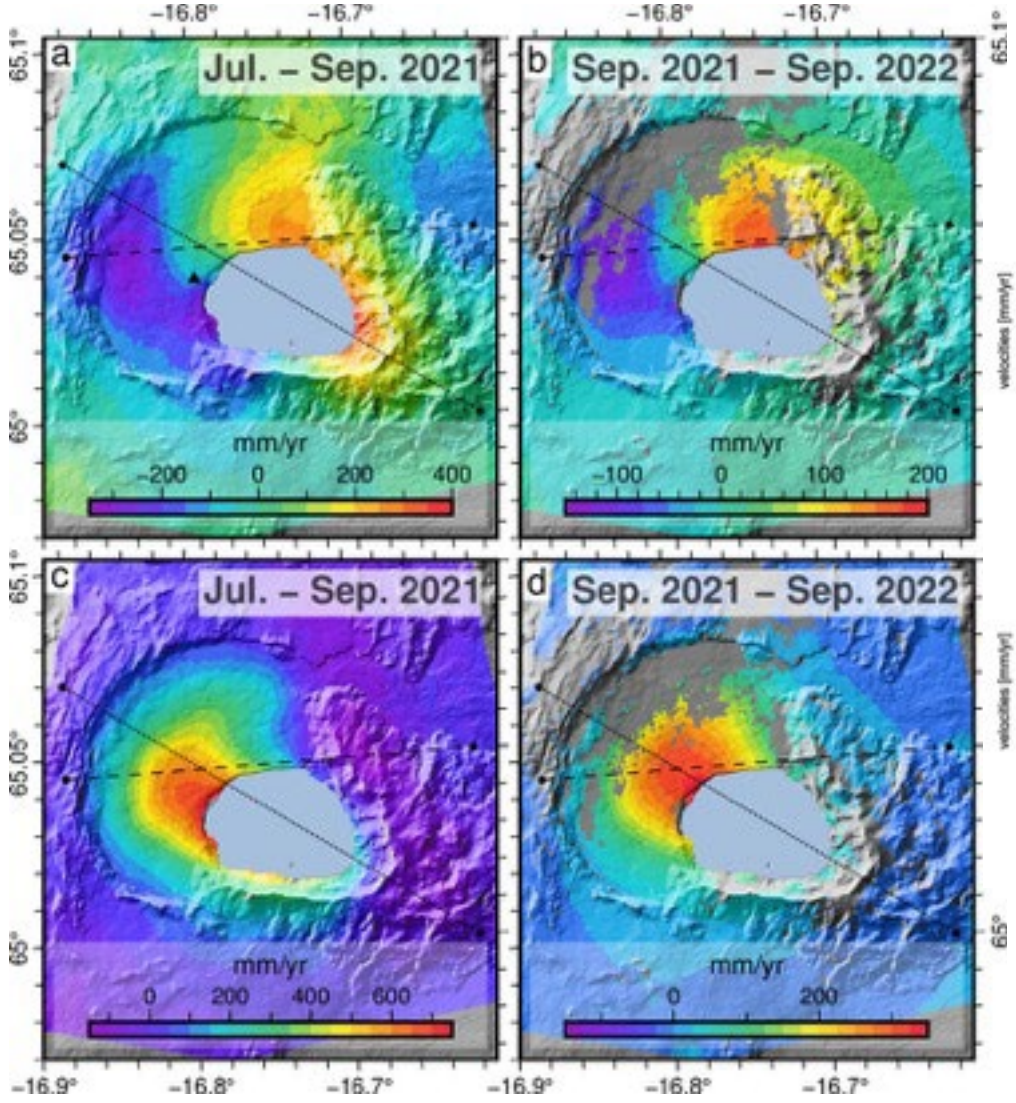


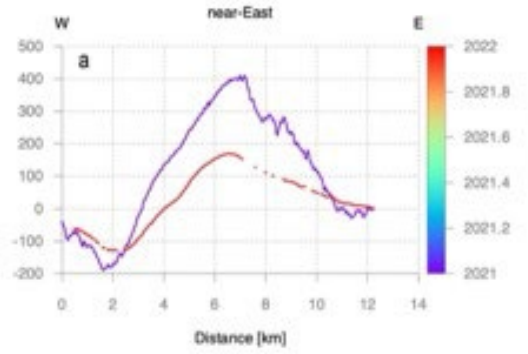
Multiple inflation sources at Askja volcano since onset of unrest in 2021

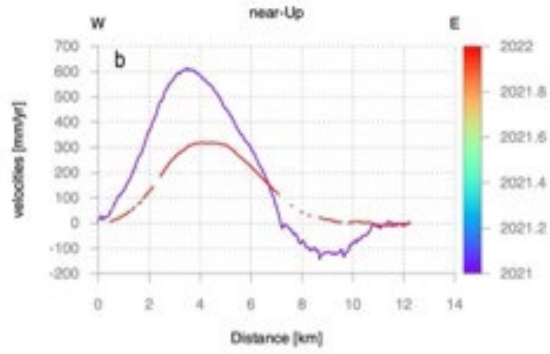


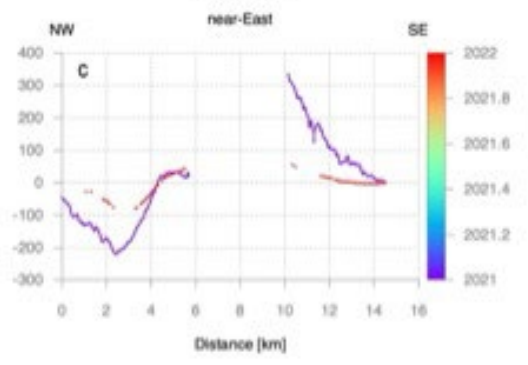
Inflation source is not static during this extended period, both in terms of rate and location of source.

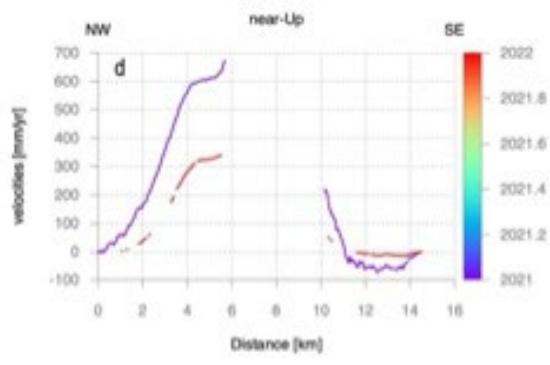
Inflation source at Askja volcano was not stationary!



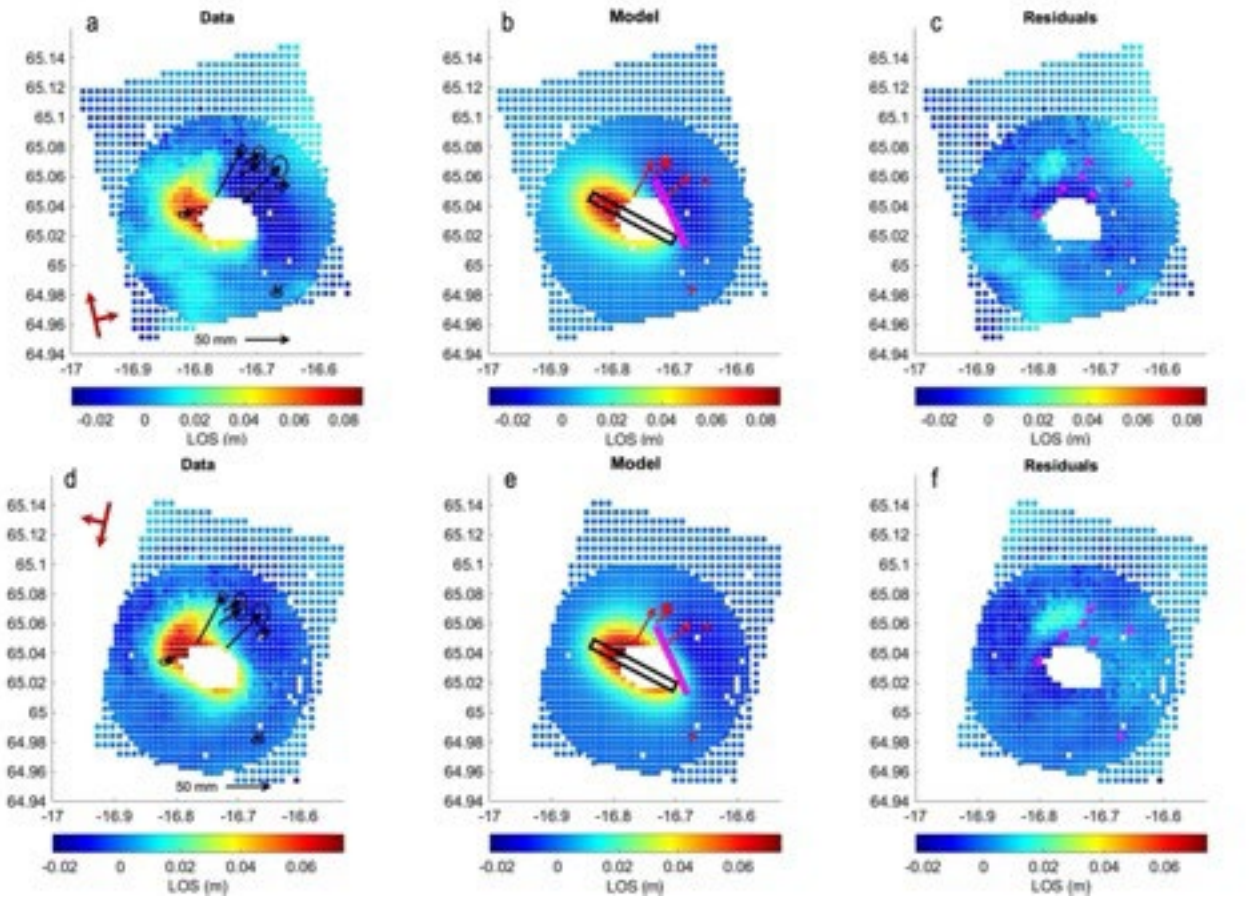








Modelling results – T1 (July-Sep 2021)

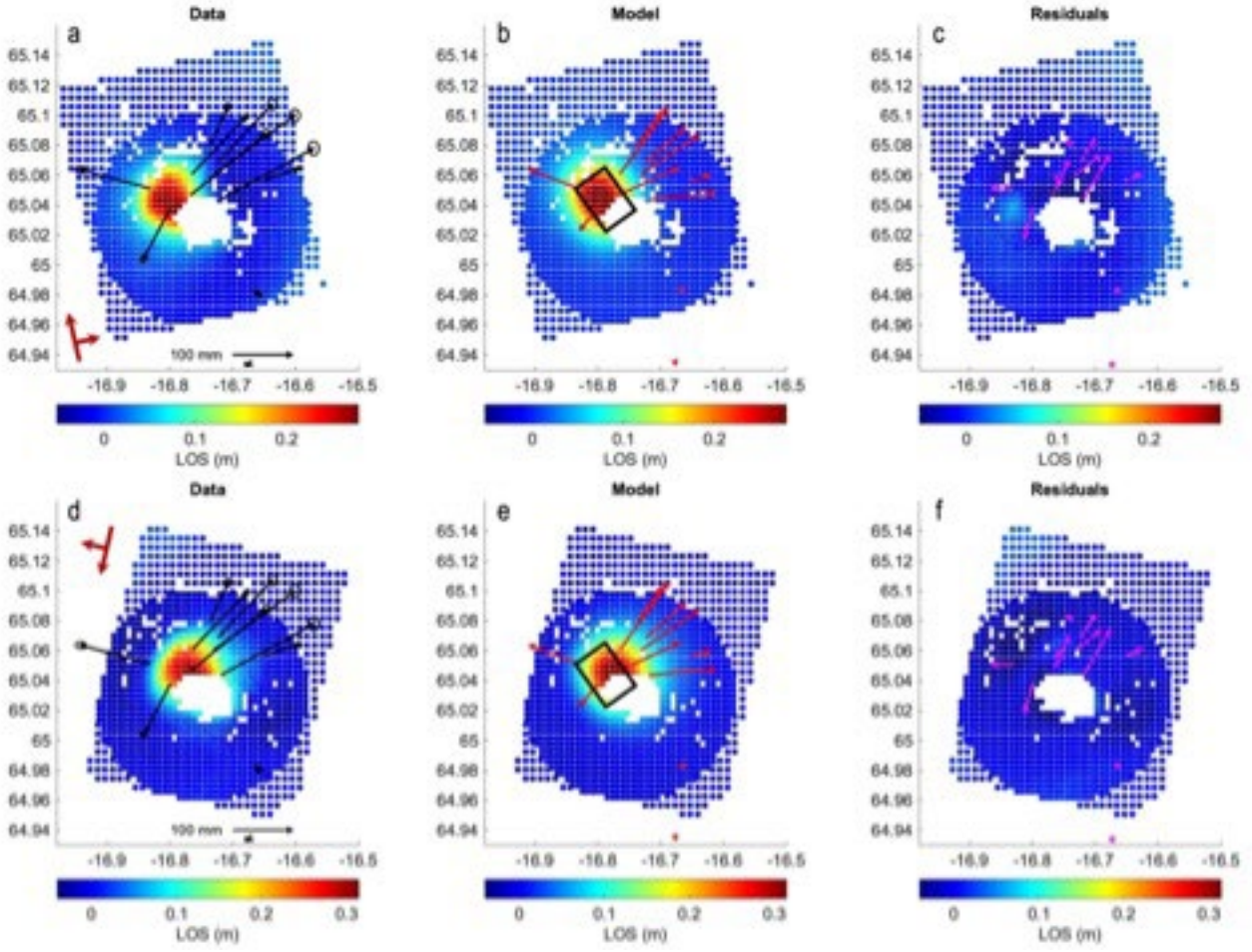


Two sources required to model T1:

1) Inflating sill-type source depth of ~ 3 km, volume change of ~ 4 million cubic meters

2) Deflating source depth of ~ 4 km volume change of -2 million cubic meters

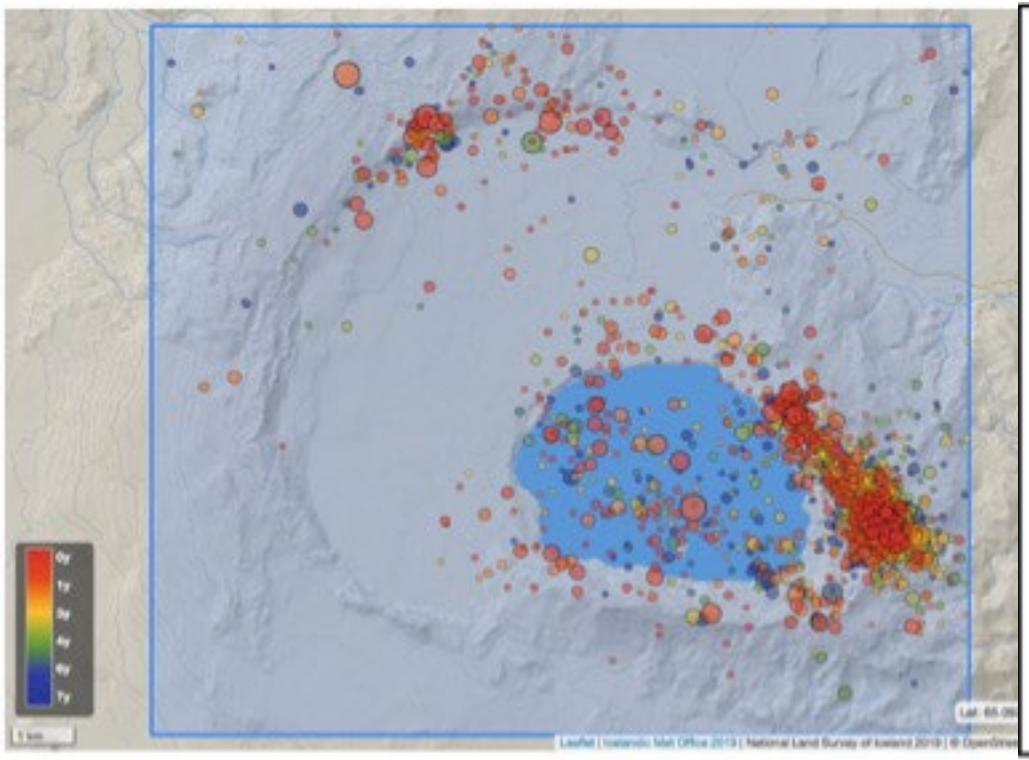
Modelling results – T2 (Sep 2021-Sep 2022)

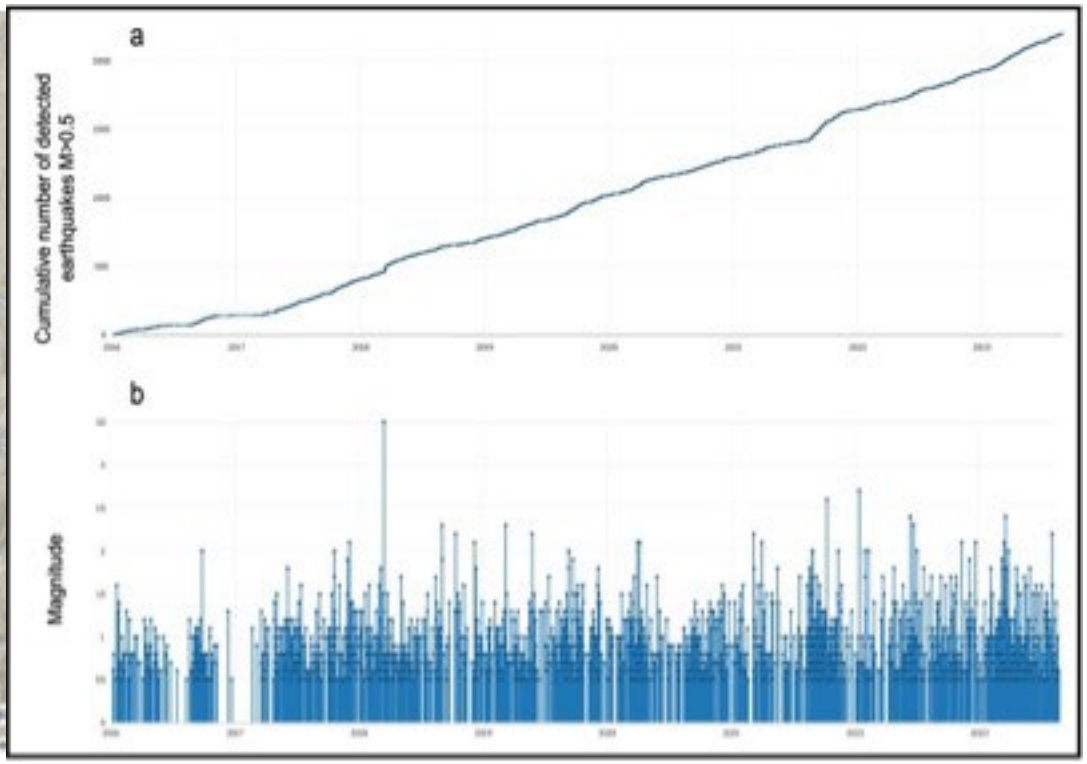


Only one source required to model T2:

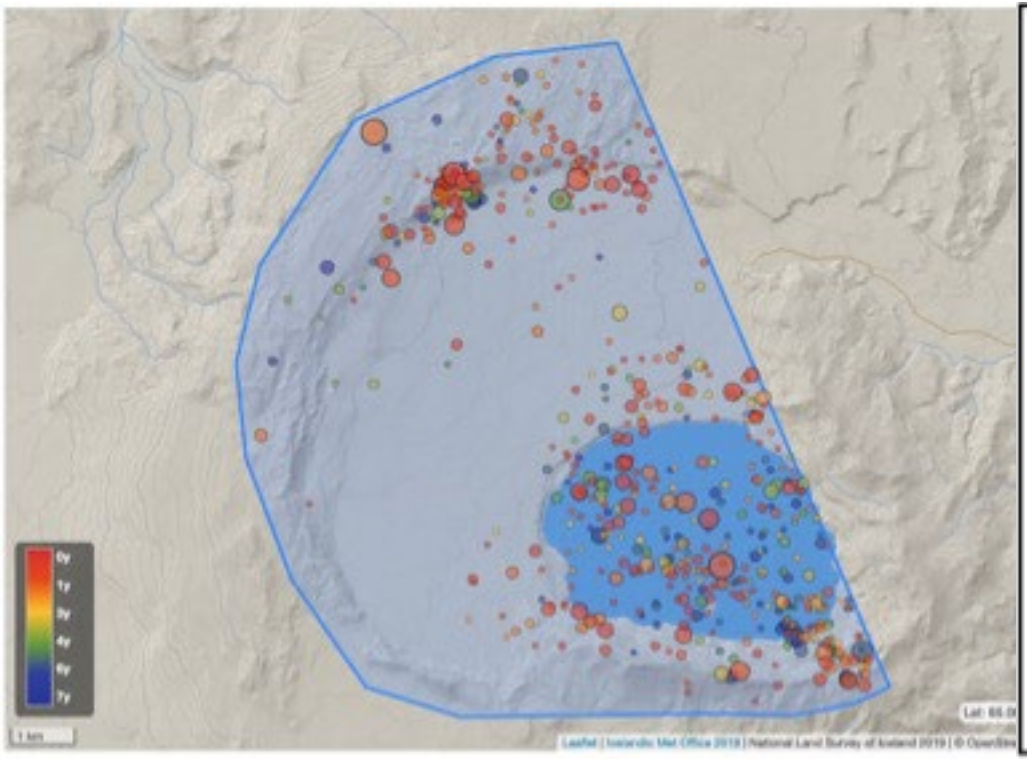
1) Inflating sill-type source depth of ~ 3 km, volume change of ~ 11 million cubic meters

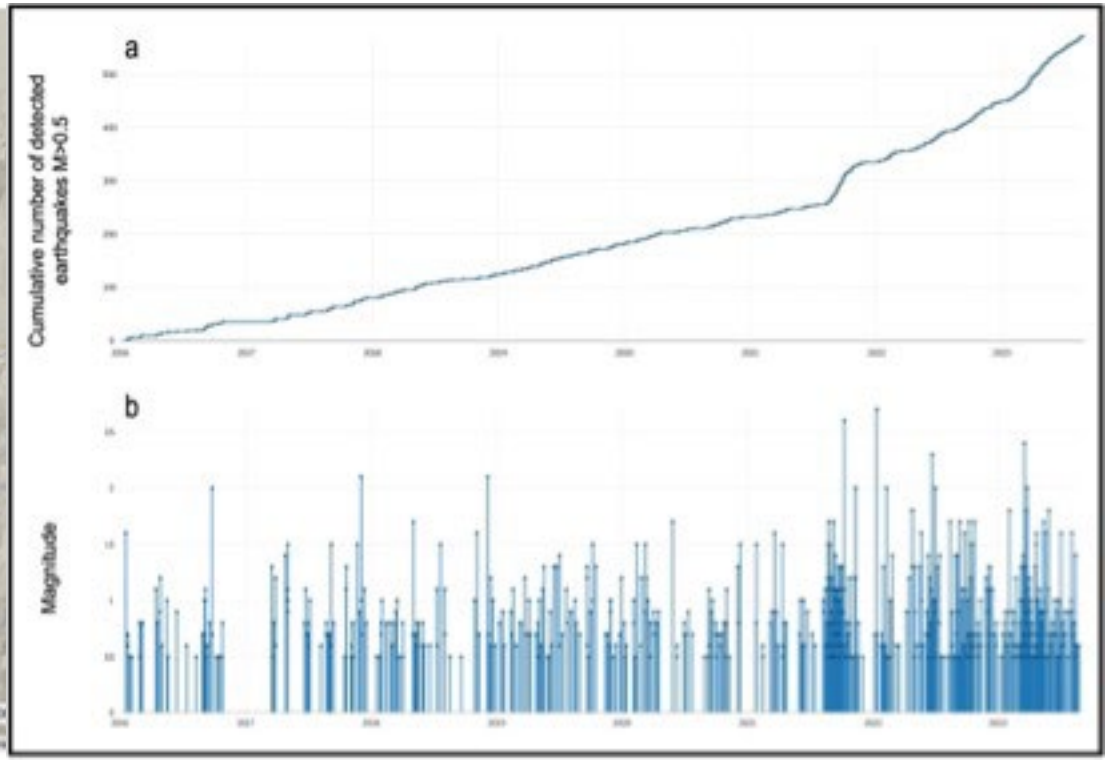
Seismicity since onset of 2021 unrest



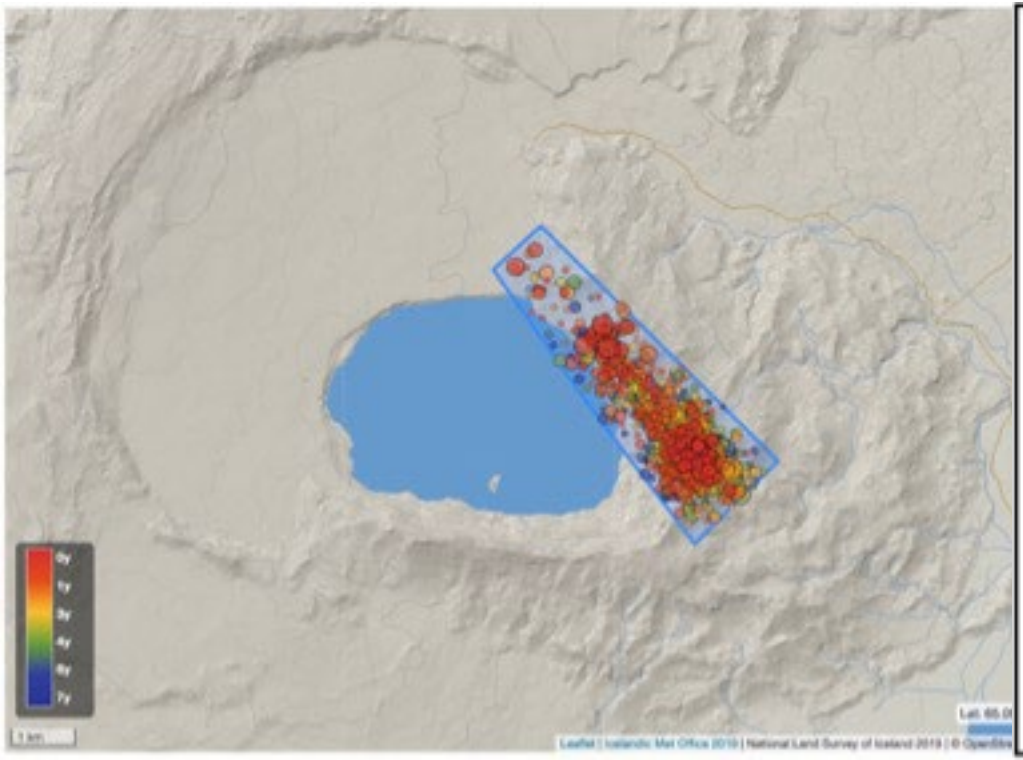


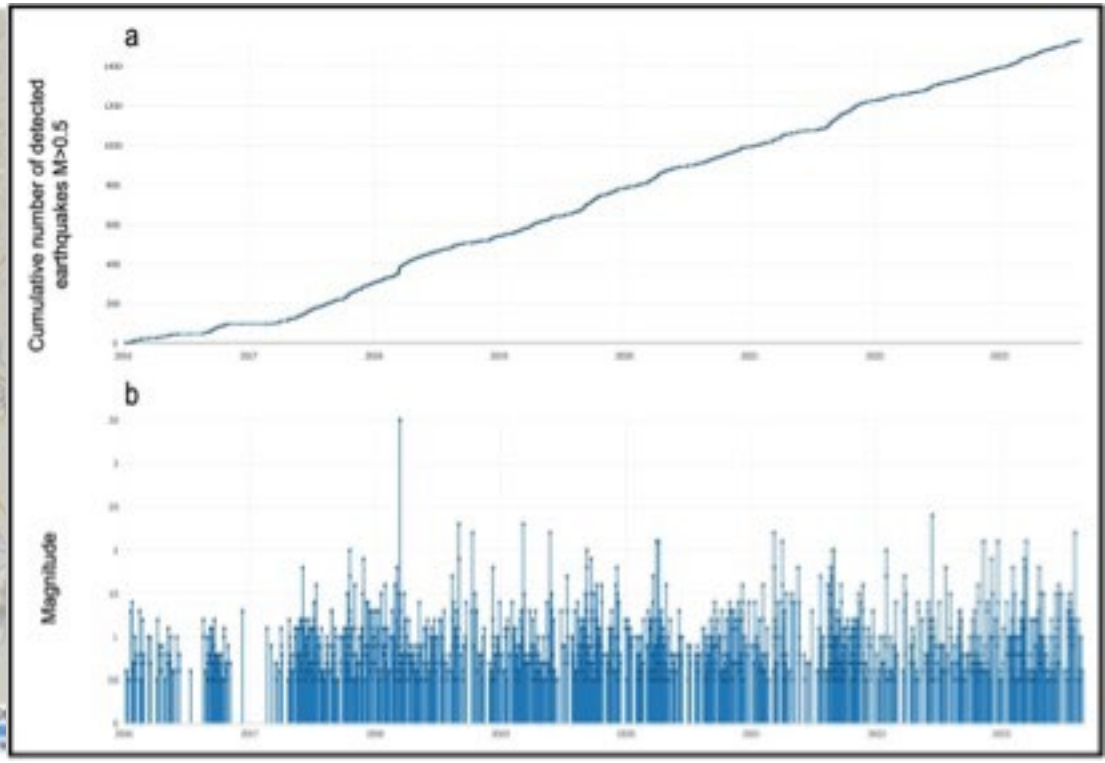
Seismicity since onset of 2021 unrest, central and western Askja





Seismicity since onset of 2021 unrest – geothermal area





Cause of unrest/inflation

- Initial inflation was triggered by magma transfer within the uppermost part of the plumbing system
- Possibility that silicic magma is involved
- Second phase of inflation may be triggered by influx of new magma from depth (no shallow deflation detected during this period)
- Estimated inflation volume to end of August 2023, is about 25 million cubic meters

- This is just one of many models to come – assumes uniform elastic half-space
- Initial FEM including topography and heterogeneity suggests source depths up to 1 km greater
- Additional models will be run including poro-viscoelastic effects
- All models are useful for providing additional insight into the magma plumbing system and better understanding of uncertainties, but should be consistent with other observations (e.g. seismicity, gravity, geochemistry, petrology …)

Possible future scenarios

- Intrusion stops – no eruption
- Continued magma inflow to shallow bodies at ~ 2-4 km beneath the caldera – increased pressurization leading to an eruption either beneath the lake or within the main Askja caldera
- Dyke propagation out of caldera
- Interaction/intersection of basaltic magma with a pre-existing silicic magma body

Thank you

Takk fyrir!

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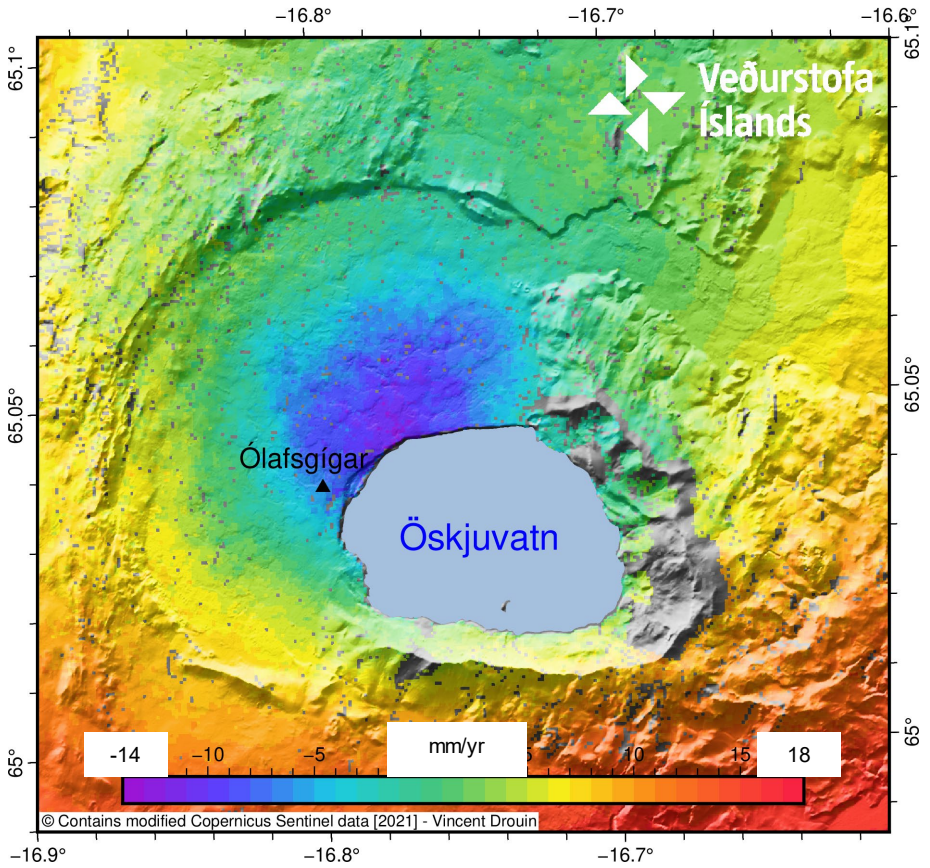
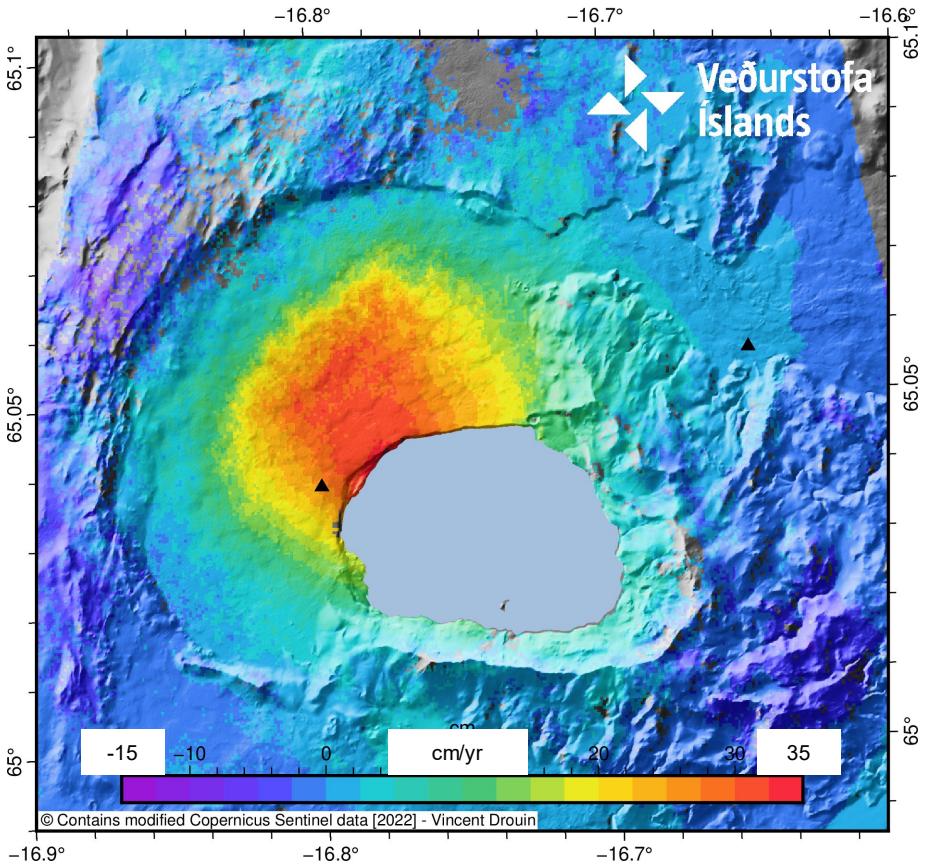
Deflation-Inflation comparison

Near-vertical deformation (2015-2018)



Near-vertical deformation (summer 2022)



Very similar source is now inflating, but at a much higher rate!