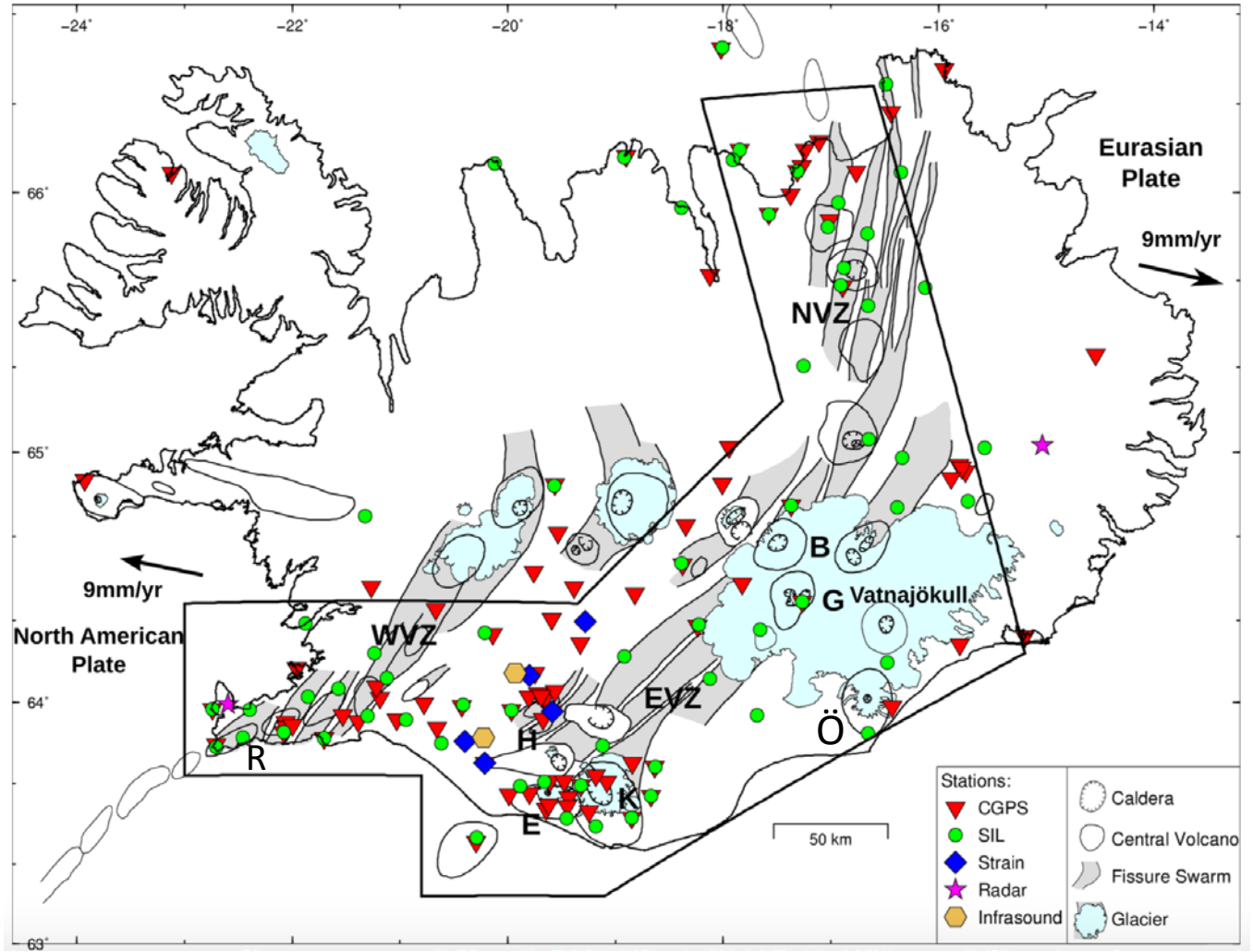
The Icelandic Volcanoes Supersite

Freysteinn Sigmundsson[1], Michelle M. Parks[2], Kristín Vogfjörð[2] and (man more) …

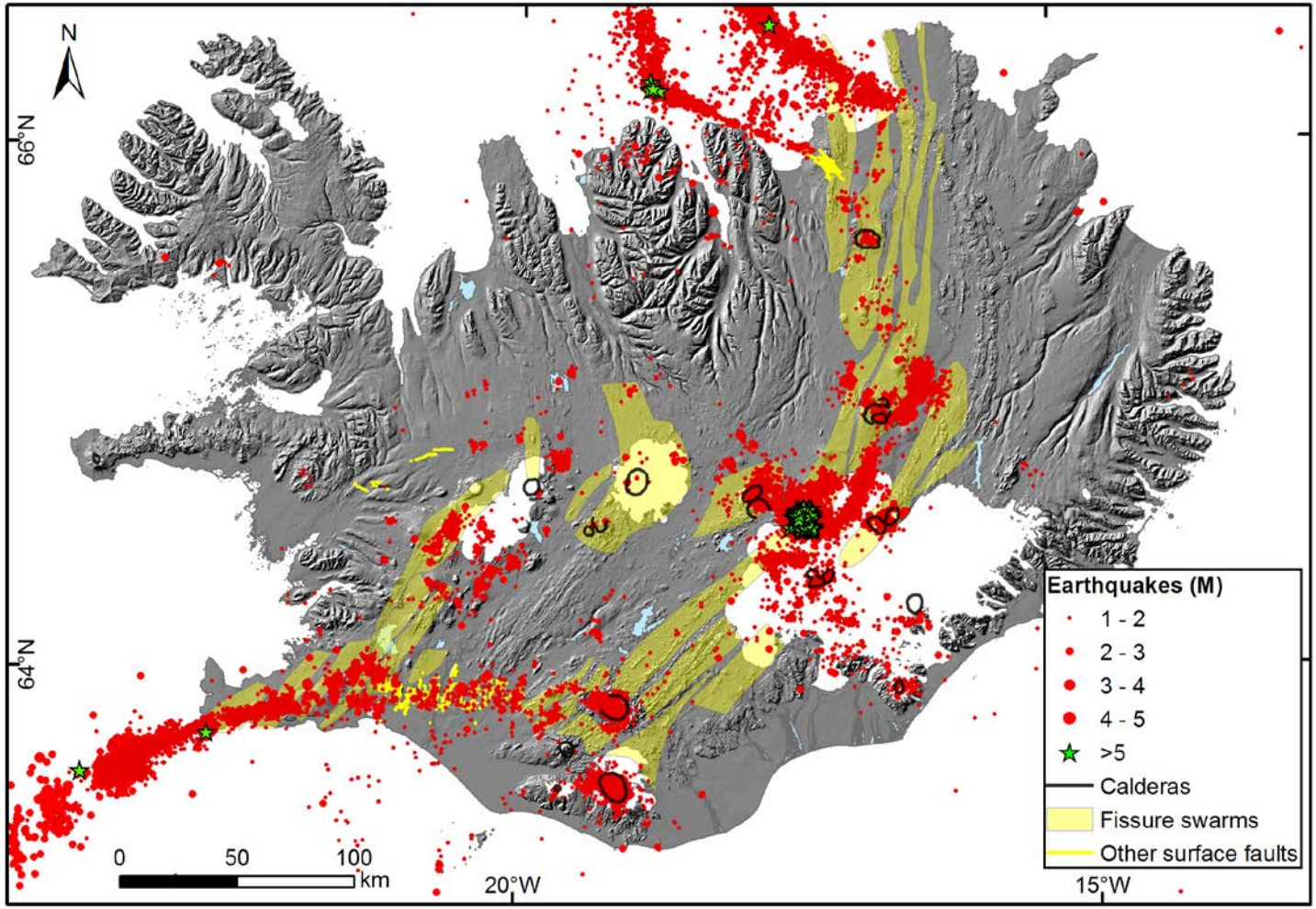
(1) Nordvulk, Inst. of Earth Sciences, University of Iceland
(2) Icelandic Meteorological Office



Icelandic Volcanoes Supersite

CEOS proposal accepted 2013

B = Bárðarbunga
Ö = Öræfajökull
R = Reykjanes



Iceland

Volcanic systems

Seismicity 2012-2016

Icelandic Meteorological Office

	Envisat	Cosmo-SkyMED	TerraSAR-X	Radarsat-2	Sentinel-1
2008	196		2		
2009	59		45		
2010	29	35	70		
2011		41	75		
2012		32	72	6	
2013		24	99	26	
2014		459	179	69	15
2015		351	173	22	358
2016		344	147	42	336
2017		235	112		801
2018		357	104		1108
Total:	**284**	**1878**	**1078**	**165**	**2618**

Coming years:

- Extensive use of Sentinel-1 interferometry
- EUROVOLC project (2018-2021; Integrating and opening research infrastructures of European interest)

Renewal of CEOS support to the Permanent Supersite "Icelandic Volcanoes"

Dear Dr. Sigmundsson,

On behalf of the Committee on Earth Observing Satellites (CEOS) it is my priviledge to inform you that the CEOS SIT, at its 33rd session in April 2018, in accordance with the approved review process, and following the positive evaluation by the GSNL SAC and a recommendation by the CEOS WG Disasters Data Coordination Team, has agreed to renew its support to the Icelandic Volcanoes Supersite.

CEOS agencies intend to support the Iceland Supersite with the following data resources:

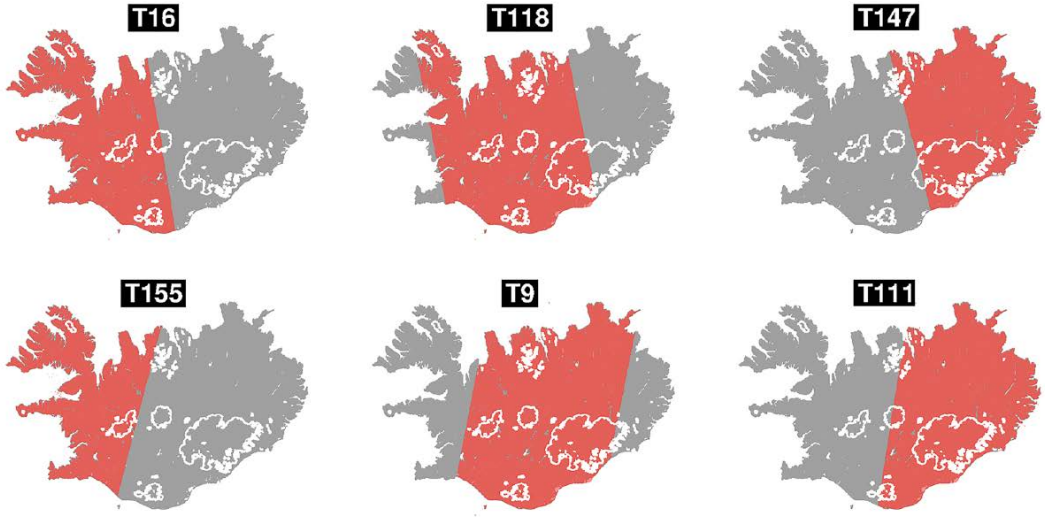
Agenzia Spaziale Italiana (ASI)	COSMO-Skymed:	700 scenes / year
Centre National d'Etudes Spatiales (CNES)	Pleiades:	5000 sq. km per year
Deutsches Zentrum für Luft- und Raumfahrt (DLR)	TerraSAR-X:	250 scenes / year
European Space Agency (ESA)	ERS-1 / -2 / ENVISAT-ASAR, Sentinel-1, -2: Any available acquisition	
National Aeronautics and Space Administration (NASA)	ASTER EO-1 MODIS:	any available acquisition any available acquisition any available acquisition
US Geological Survey (USGS)	Landsat-8:	any available acquisition

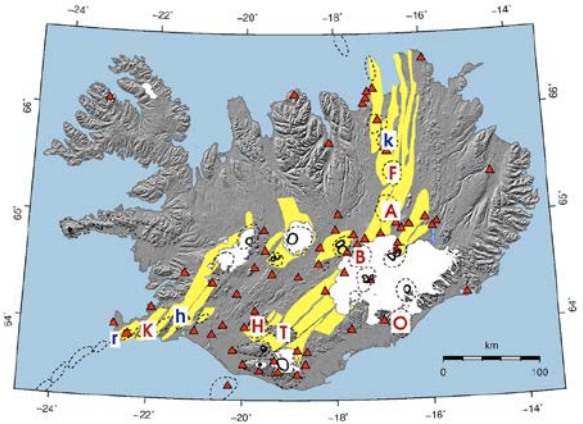
Data will be made available free of charge for the purposes described in your proposal for the Iceland Supersite, and on a best-effort basis. Individual data access procedures and applicable license and access conditions are applicable.

Sincerely,

Jens Danzeglocke, DLR,

on behalf of the Data Coordination Team of the CEOS WG Disasters



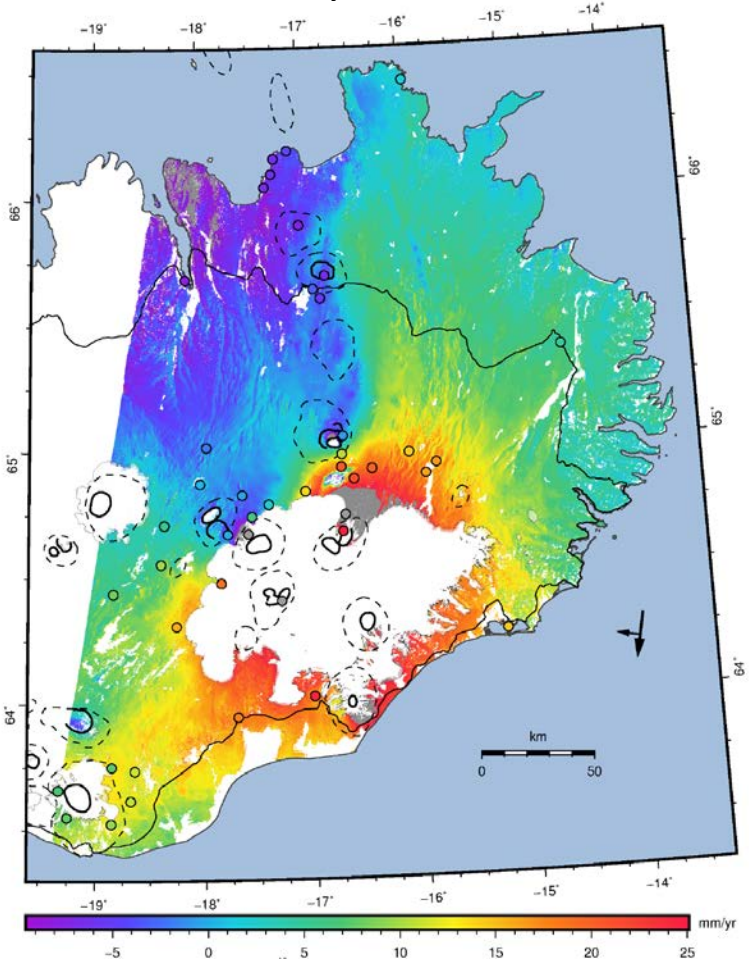


Geophysical Research Letters

Countrywide Observations of Plate Spreading and Glacial Isostatic Adjustment in Iceland Inferred by Sentinel-1 Radar Interferometry, 2015–2018

Vincent Drouin[1,2] and Freysteinn Sigmundsson[1]

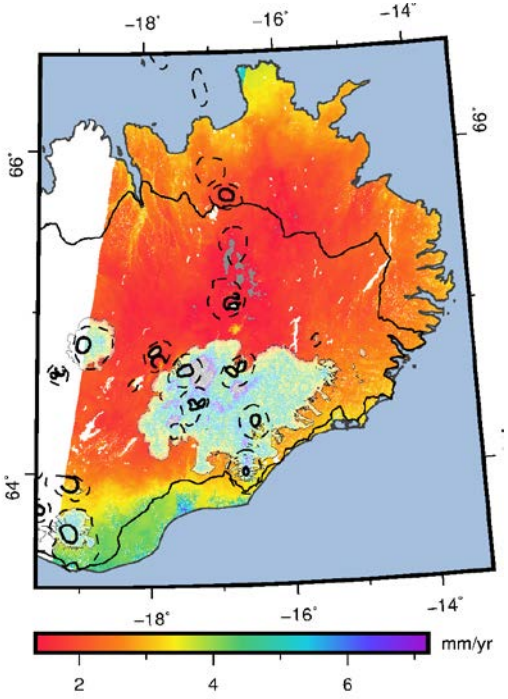
LOS-velocity, 2015-2018

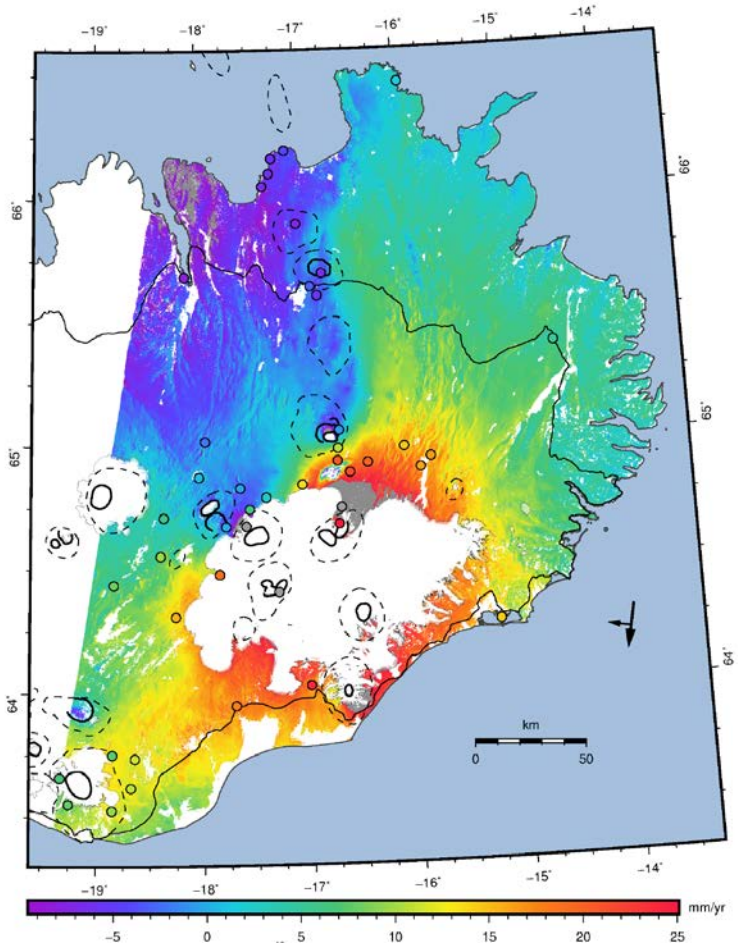


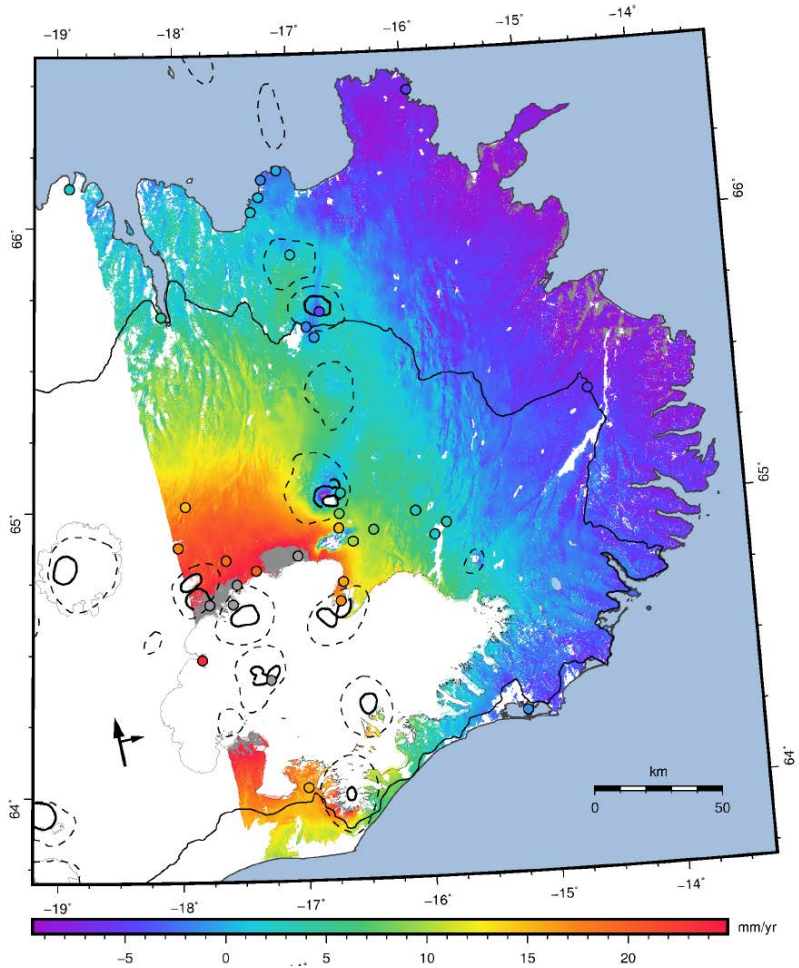
Countrywide Observations of Plate Spreading and Glacial Isostatic Adjustment in Iceland Inferred by Sentinel-1 Radar Interferometry, 2015–2018

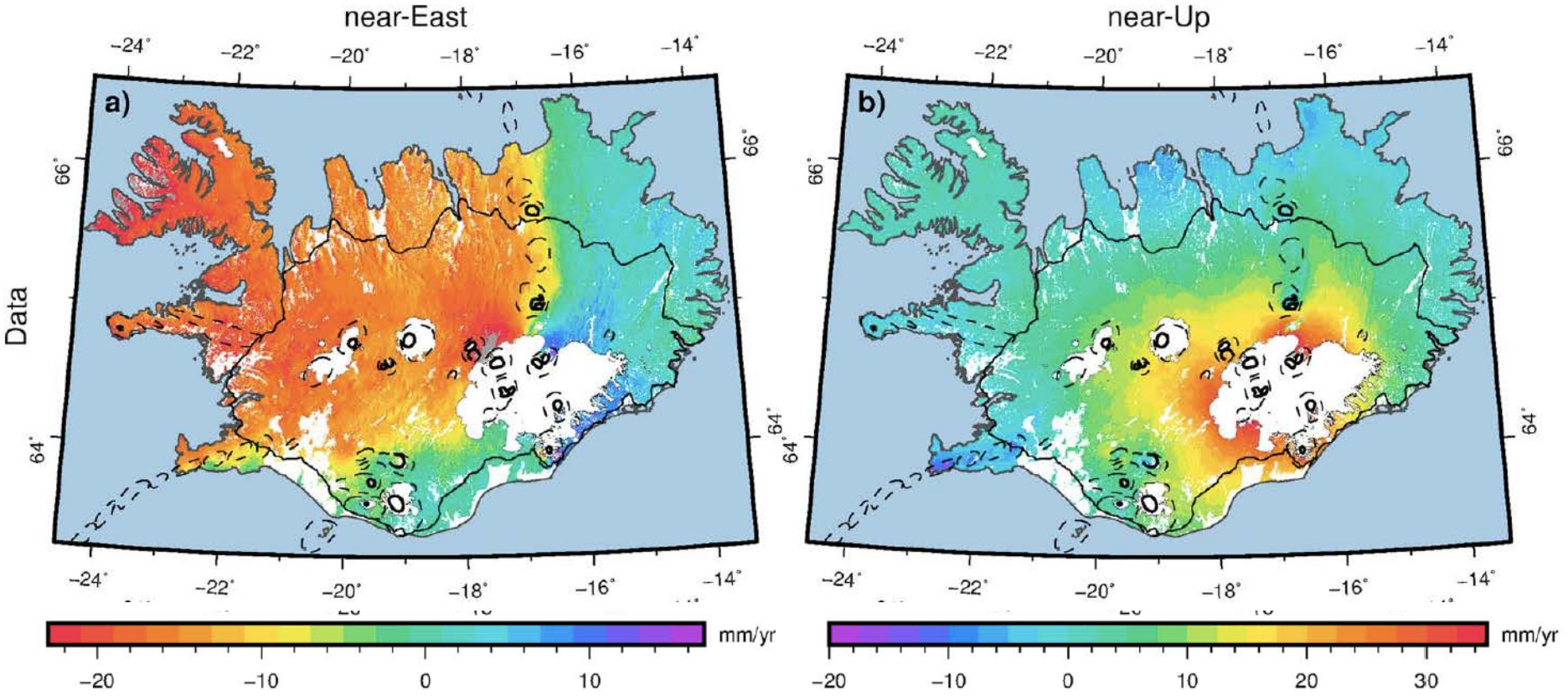
Vincent Drouin[1,2] and Freysteinn Sigmundsson[1]

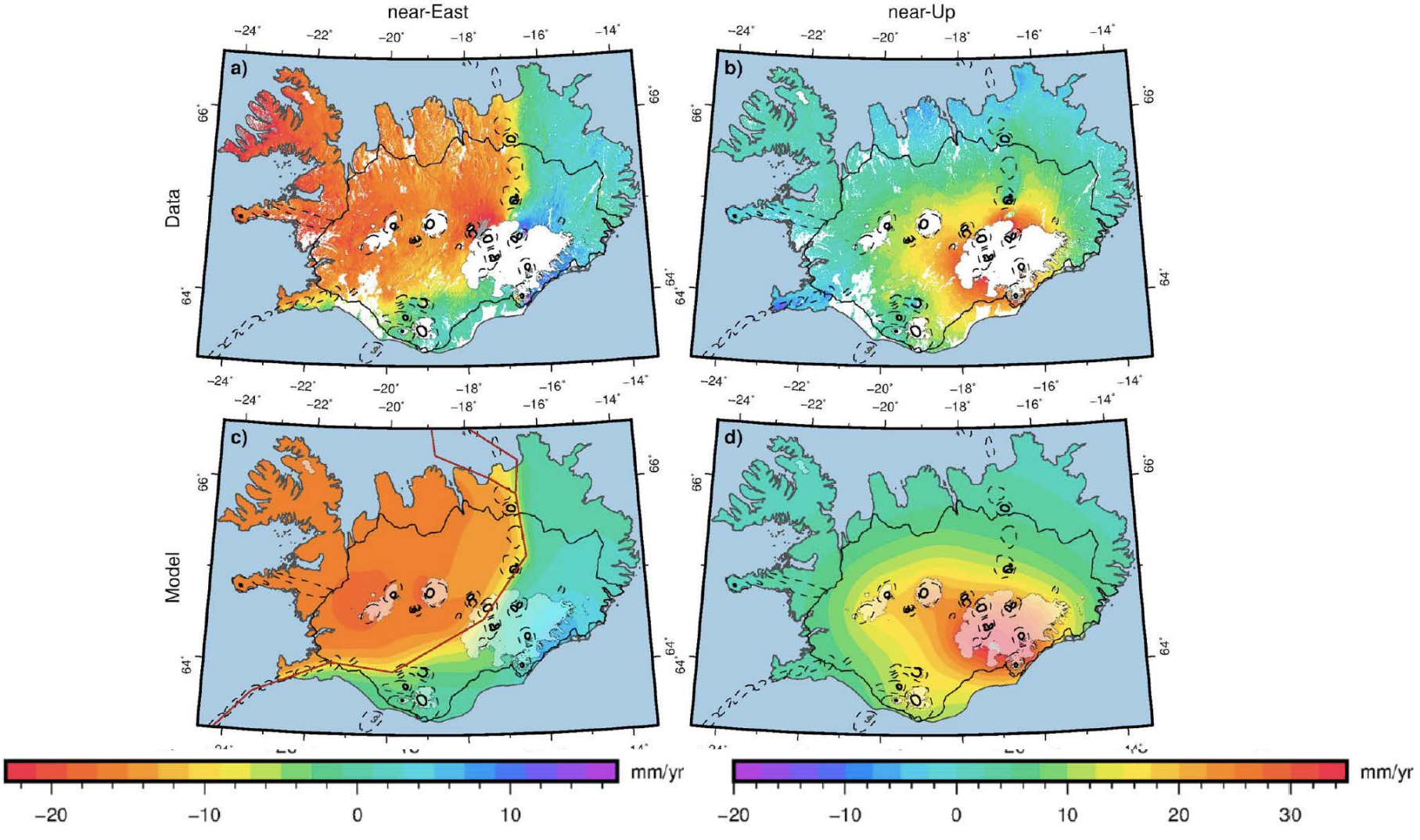
Uncertainty

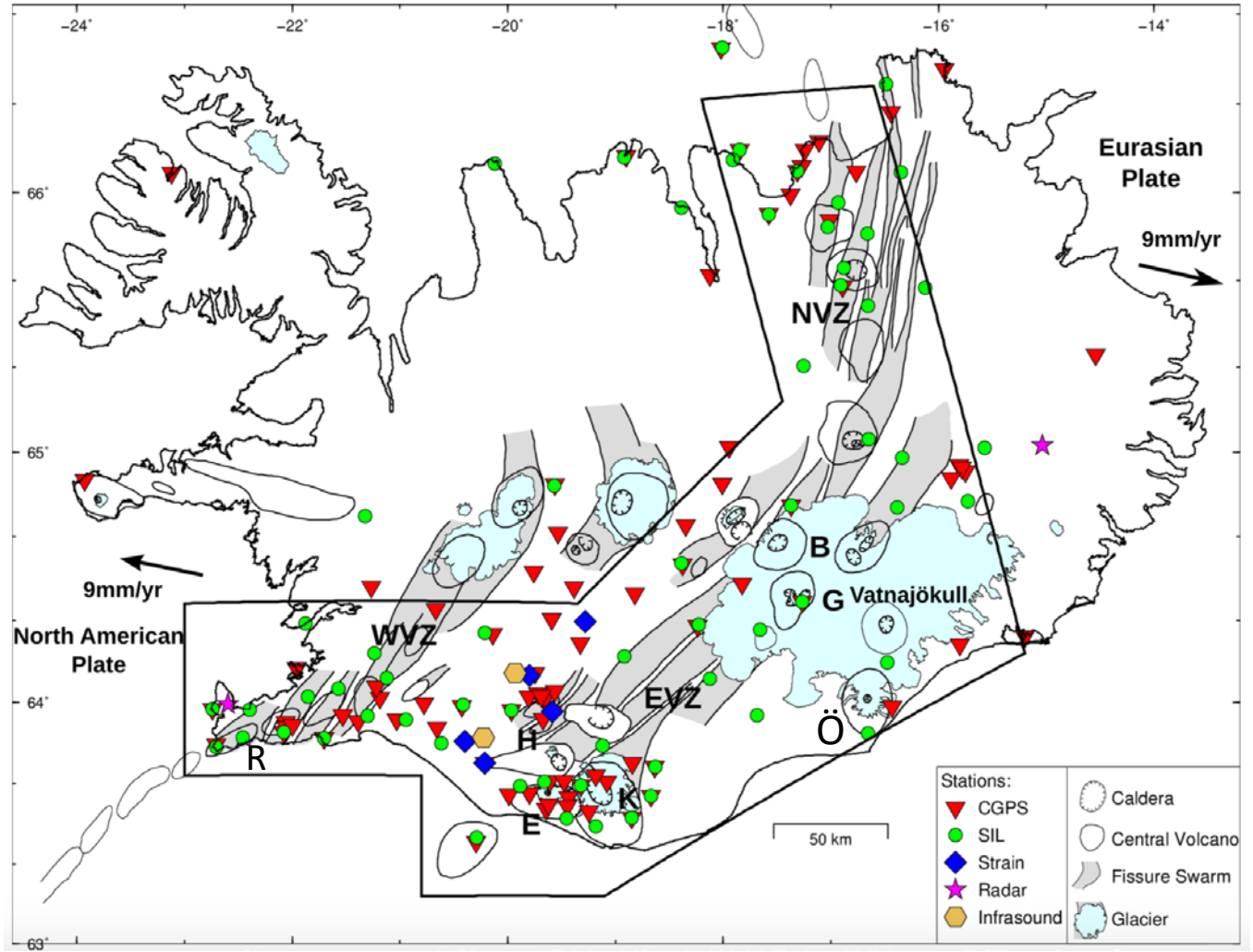



−19°
−18°
−17°
−16°
−15°
−14°
66°
65°
64°
km
0
50
mm/yr
−5
0
5
10
15
20
25


−19°
−18°
−17°
−16°
−15°
−14°
66°
65°
64°
km
0
50
mm/yr
−5
0
5
10
15
20


near-East
near-Up
a)
b)
Data
−24°
−22°
−20°
−18°
−16°
−14°
66°
64°
mm/yr
−20
−10
0
10
20
30

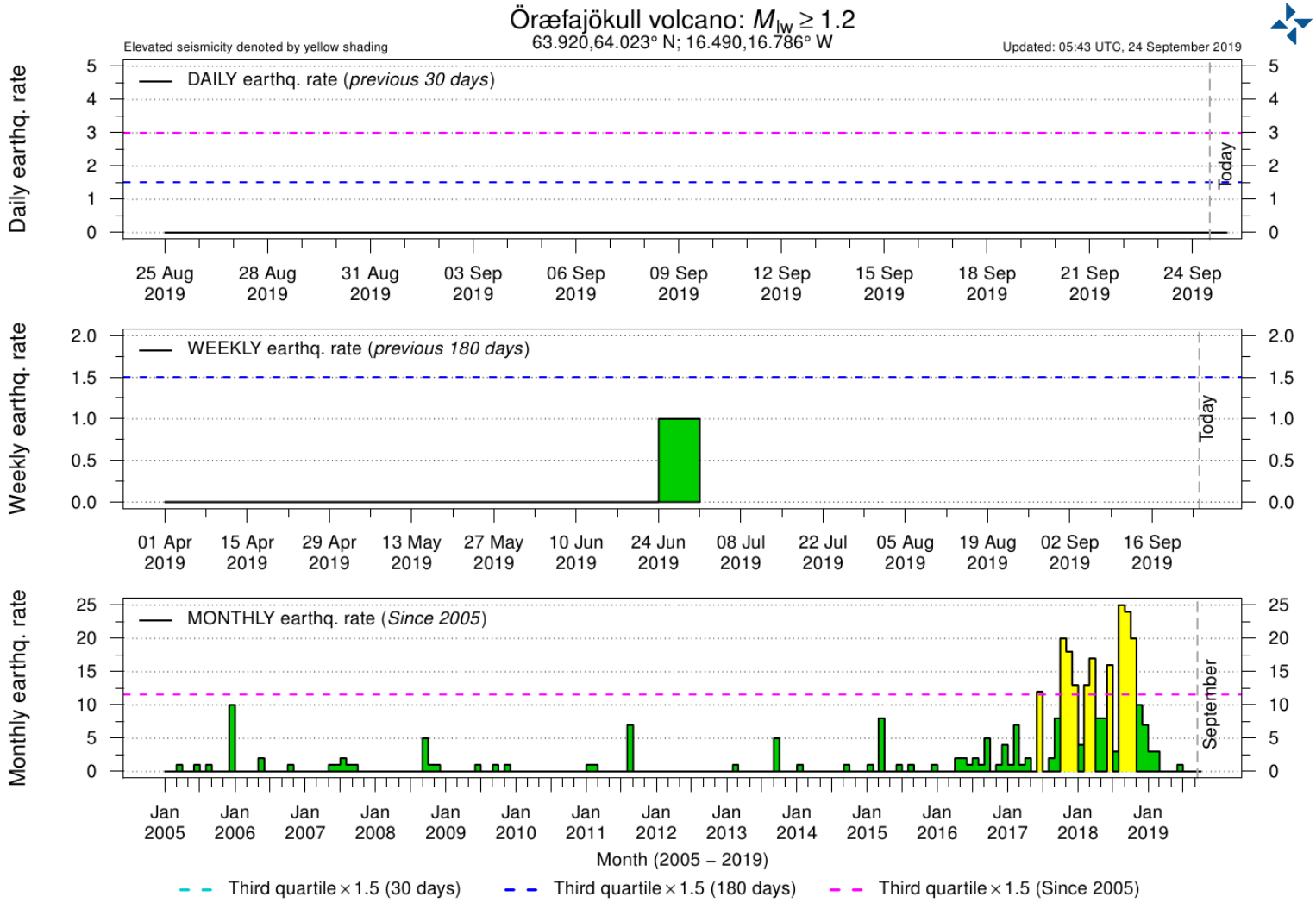

near-East
near-Up
a)
b)
c)
d)
Data
Model
−24°
−22°
−20°
−18°
−16°
−14°
66°
64°
mm/yr
−20
−10
0
10
20
30

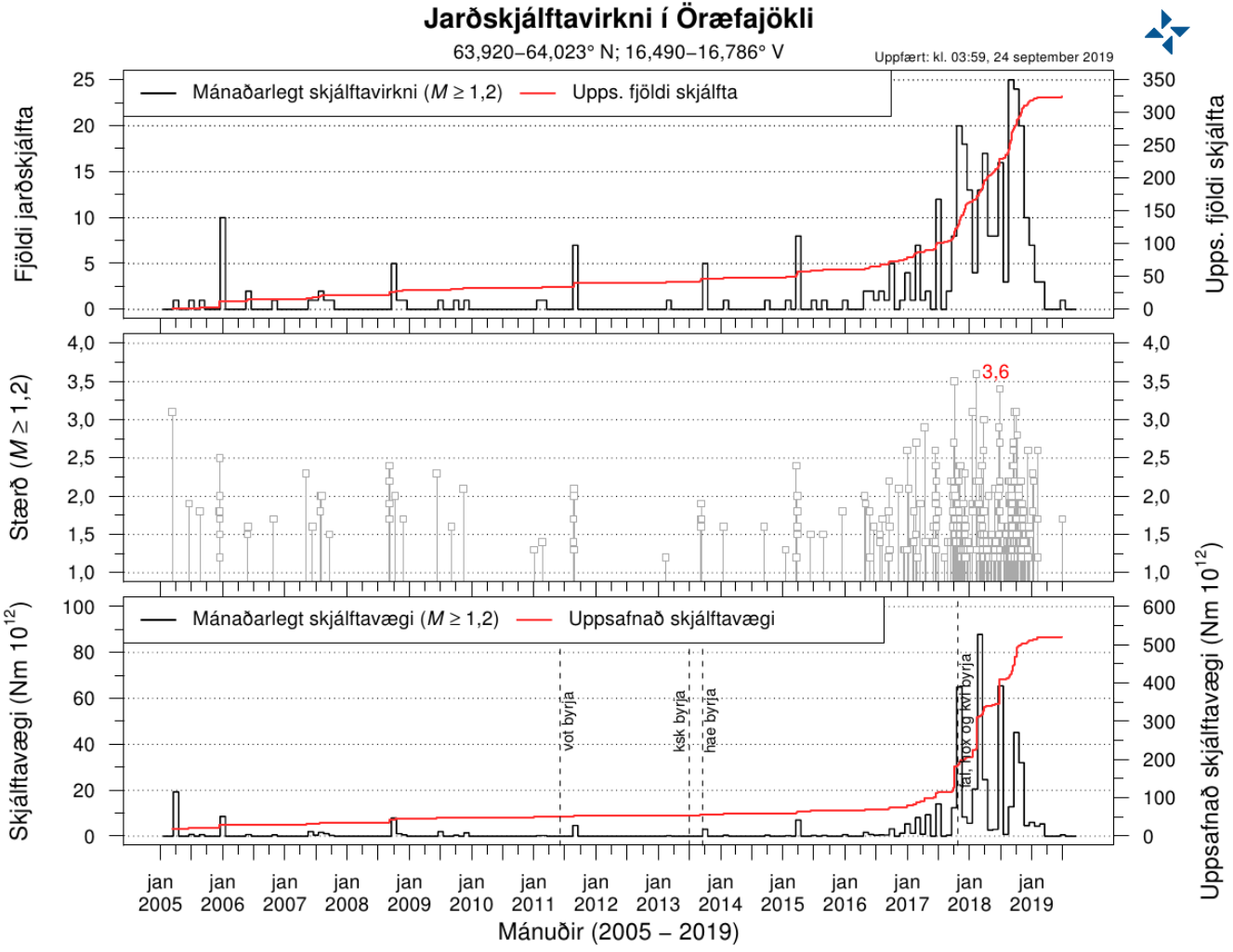


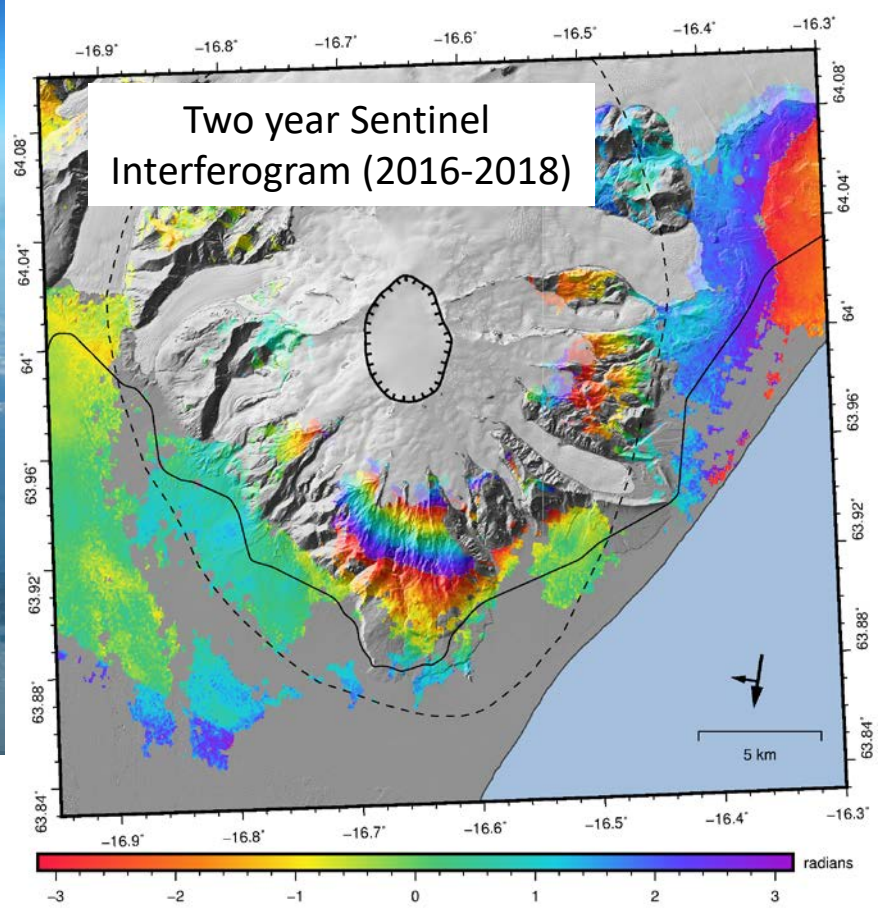
Icelandic Volcanoes Supersite

CEOS proposal accepted 2013

B = Bárðarbunga
Ö = Öræfajökull
R = Reykjanes


Öræfajökull volcano: $M_{lw} \geq 1.2$
63.920,64.023° N; 16.490,16.786° W
Elevated seismicity denoted by yellow shading
Updated: 05:43 UTC, 24 September 2019
Daily earthq. rate
DAILY earthq. rate (previous 30 days)
Today
25 Aug 2019
28 Aug 2019
31 Aug 2019
03 Sep 2019
06 Sep 2019
09 Sep 2019
12 Sep 2019
15 Sep 2019
18 Sep 2019
21 Sep 2019
24 Sep 2019
Weekly earthq. rate
WEEKLY earthq. rate (previous 180 days)
Today
01 Apr 2019
15 Apr 2019
29 Apr 2019
13 May 2019
27 May 2019
10 Jun 2019
24 Jun 2019
08 Jul 2019
22 Jul 2019
05 Aug 2019
19 Aug 2019
02 Sep 2019
16 Sep 2019
Monthly earthq. rate
MONTHLY earthq. rate (Since 2005)
September
Jan 2005
Jan 2006
Jan 2007
Jan 2008
Jan 2009
Jan 2010
Jan 2011
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018
Jan 2019
Month (2005 – 2019)
Third quartile × 1.5 (30 days)
Third quartile × 1.5 (180 days)
Third quartile × 1.5 (Since 2005)


Jarðskjálftavirkni í Öræfajökli
63,920–64,023° N; 16,490–16,786° V
Uppfært: kl. 03:59, 24 september 2019
Mánaðarlegt skjálftavirkni (M ≥ 1,2)
Upps. fjöldi skjálfta
Fjöldi jarðskjálfta
Upps. fjöldi skjálfta
Stærð (M ≥ 1,2)
3,6
Skjálftavægi (Nm 10^12)
Mánaðarlegt skjálftavægi (M ≥ 1,2)
Uppsafnað skjálftavægi
vot byrja
ksk byrja
hae byrja
tat, hox og kvr byrja
Uppsafnað skjálftavægi (Nm 10^12)
jan 2005
jan 2006
jan 2007
jan 2008
jan 2009
jan 2010
jan 2011
jan 2012
jan 2013
jan 2014
jan 2015
jan 2016
jan 2017
jan 2018
jan 2019
Mánuðir (2005 – 2019)



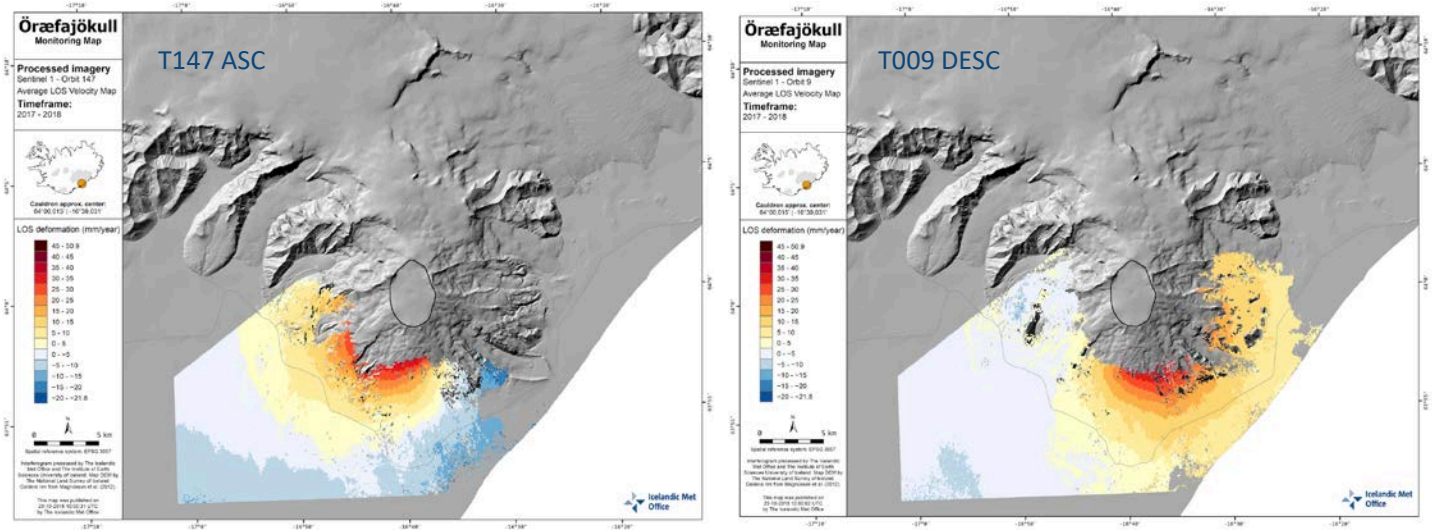
Öræfajökull

Volcanic unrest since beginning of 2017

Earthquakes, deformation, gas, geothermal activity

UNIVERSITY OF ICELAND
INSTITUTE OF EARTH SCIENCES

InSAR analysis

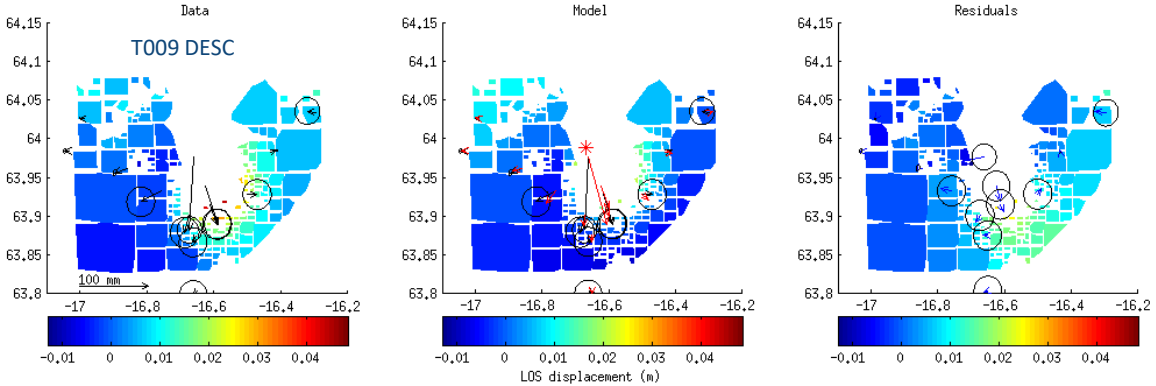


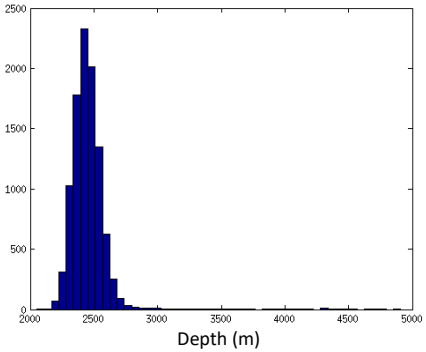
Average los velocity maps (2017-2018)

Icelandic Meteorological Office – Michelle Parks

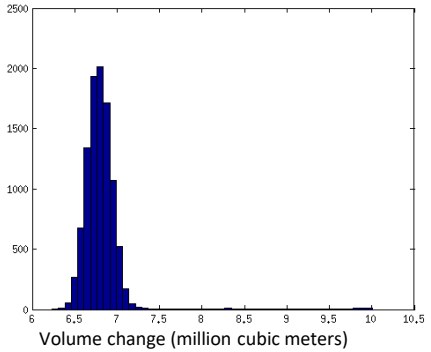
Source modelling – Mogi model (spherical type source)

Icelandic Meteorological Office – Michelle Parks





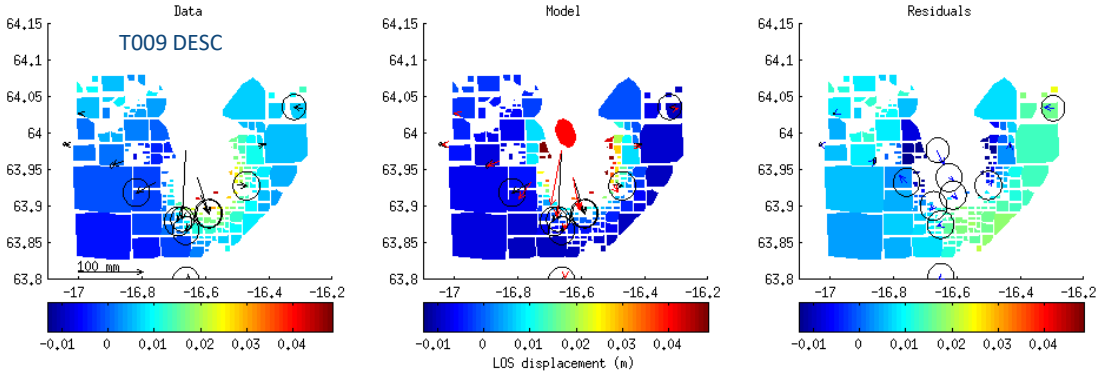
Mogi depth = 2.4 km

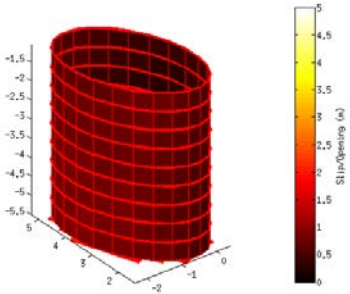


Mogi volume change = 7 million cubic meters

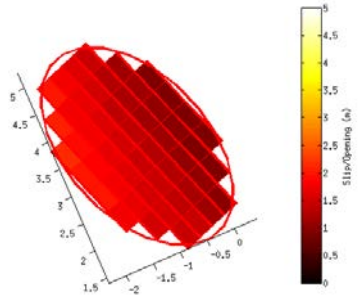
Source modelling – Ring fault and sill (divided into patches)

Icelandic Meteorological Office – Michelle Parks



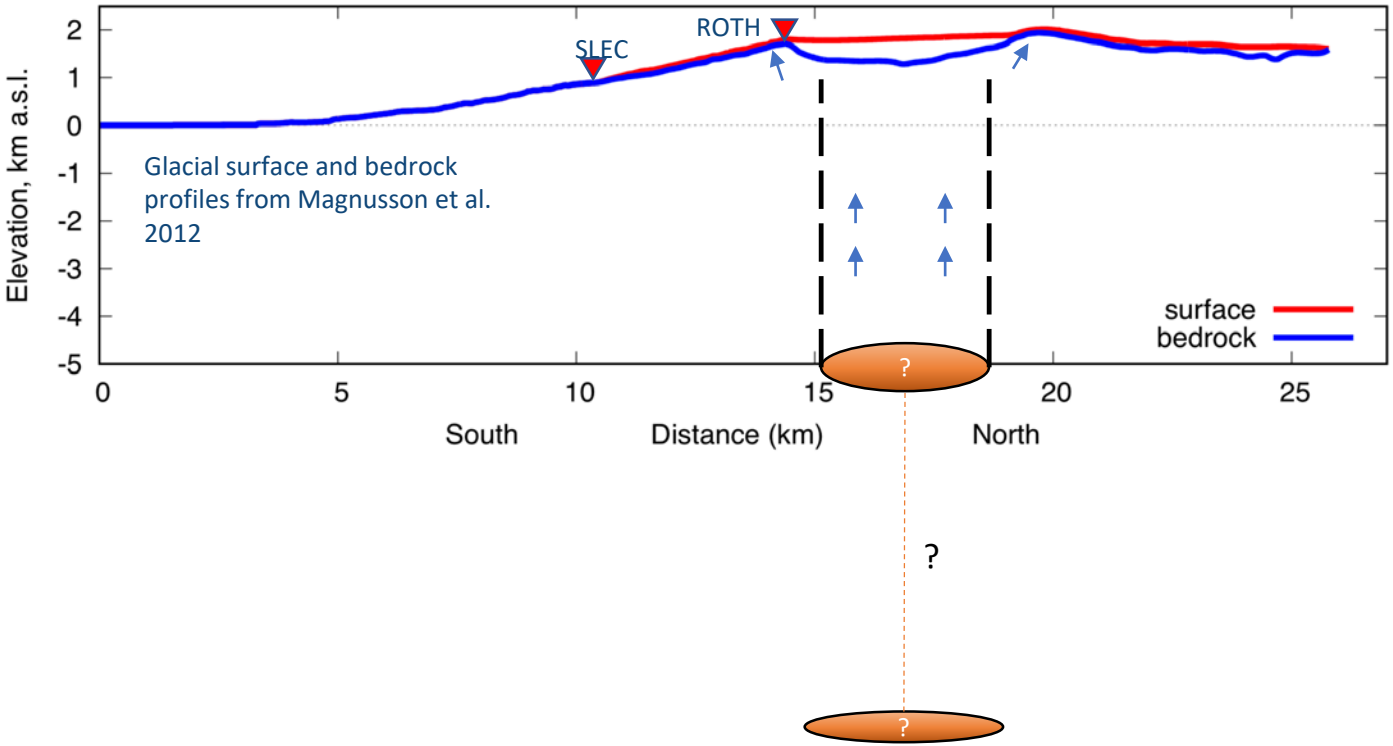


Sill depth = 5.5 km



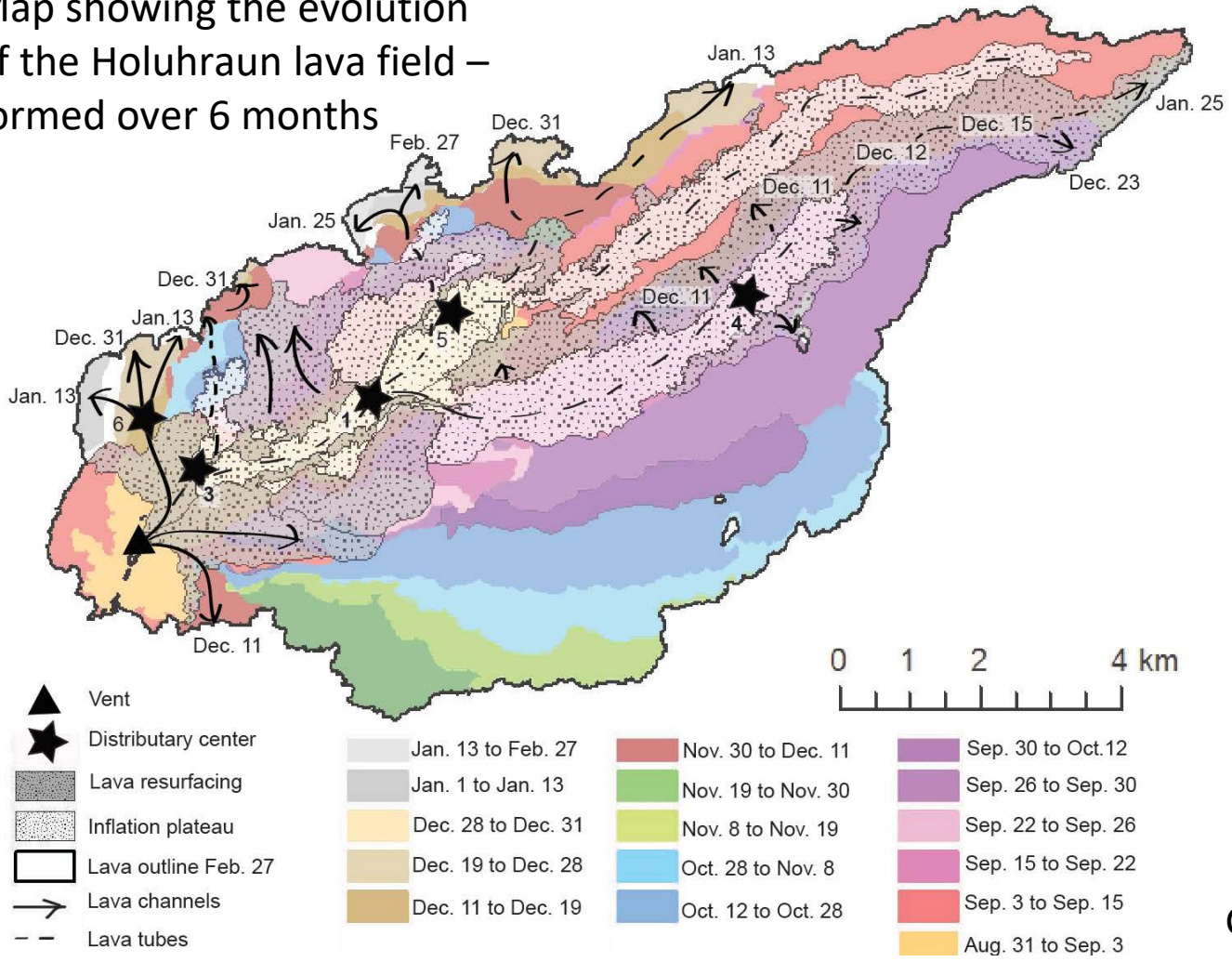
Sill volume change = 23 million cubic meters

Schematic of plumbing system beneath Öræfajökull




2014-2015 (6 months)
Bardarbunga volcanic system:
Holuhraun lava: ~ 1.4 km3

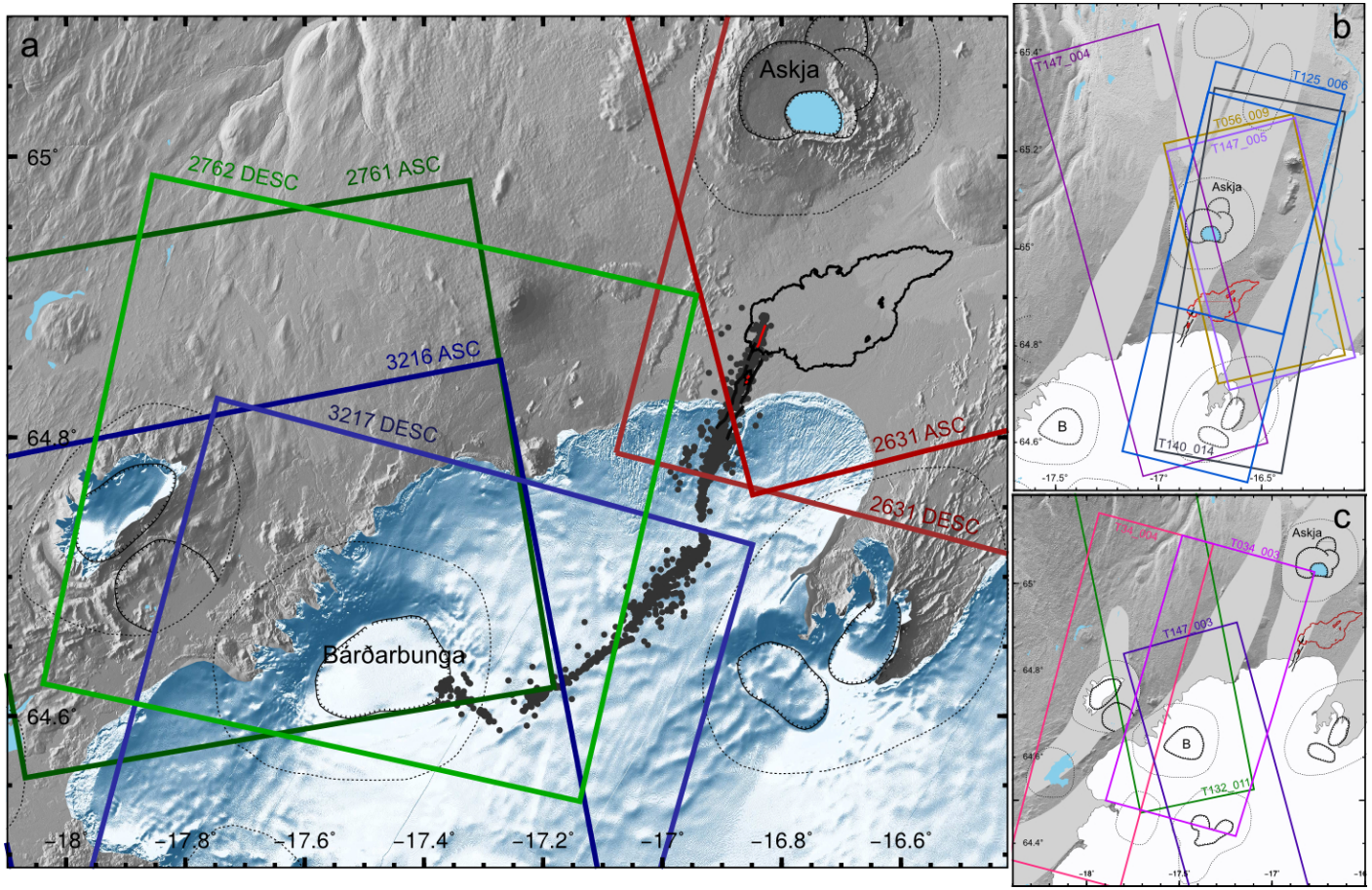
Map showing the evolution of the Holuhraun lava field – formed over 6 months



The Holuhraun lava field

First day of main eruption, 31 August, 2014
(photo: Gro Pedersen)

Gro Pedersen et al. (2017)



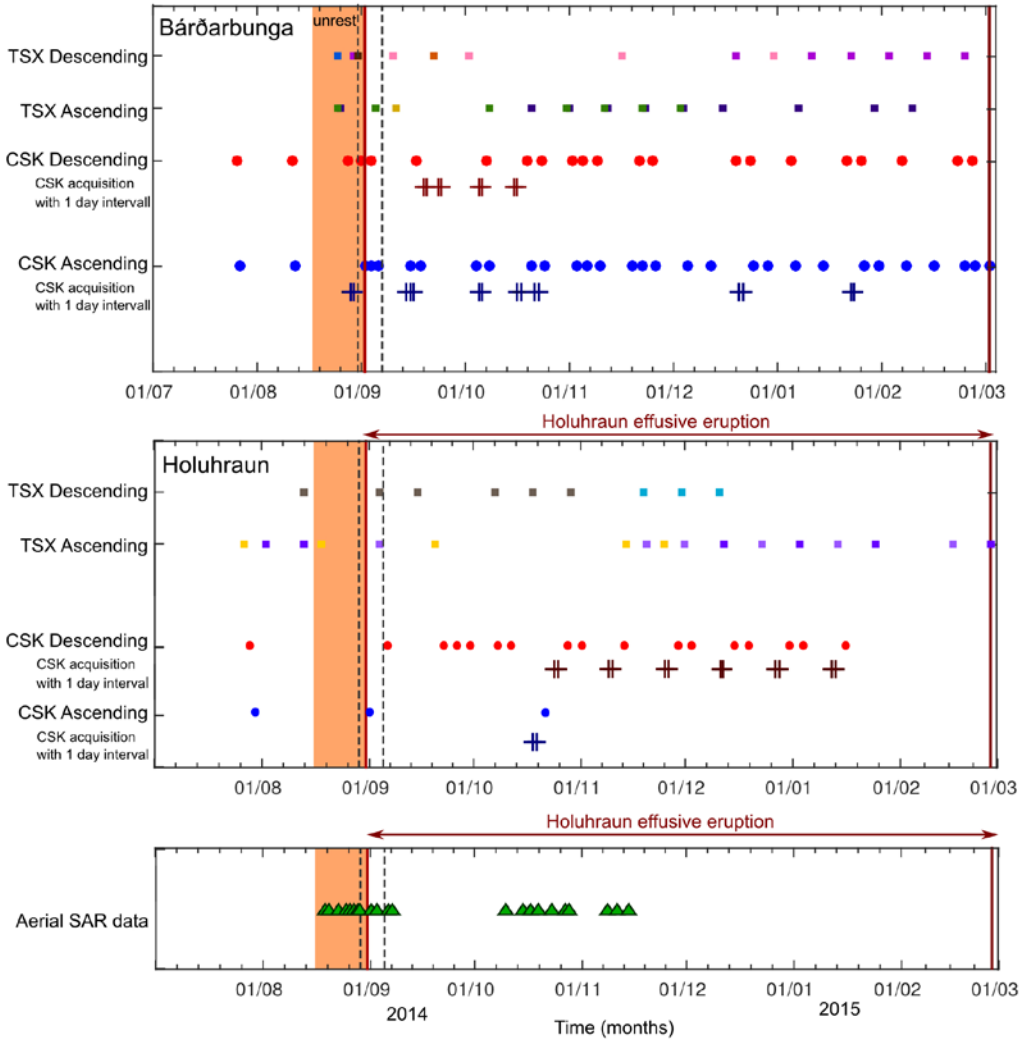
SAR satellite tracks used during unrest at Bárðarbunga and Holuhraun eruption.

(a) Cosmo -SkyMed satellite images

(b) and (c) Most frequent TerraSAR-X images

Gray dots: seismic events related to dike propagation.

Dumont et al. 2018



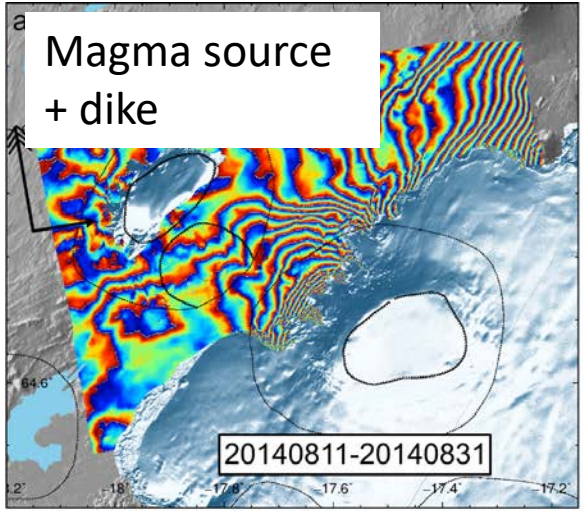
Integration of SAR Data Into Monitoring of the 2014–2015 Holuhraun Eruption, Iceland: Contribution of the Icelandic Volcanoes Supersite and the FutureVolc Projects

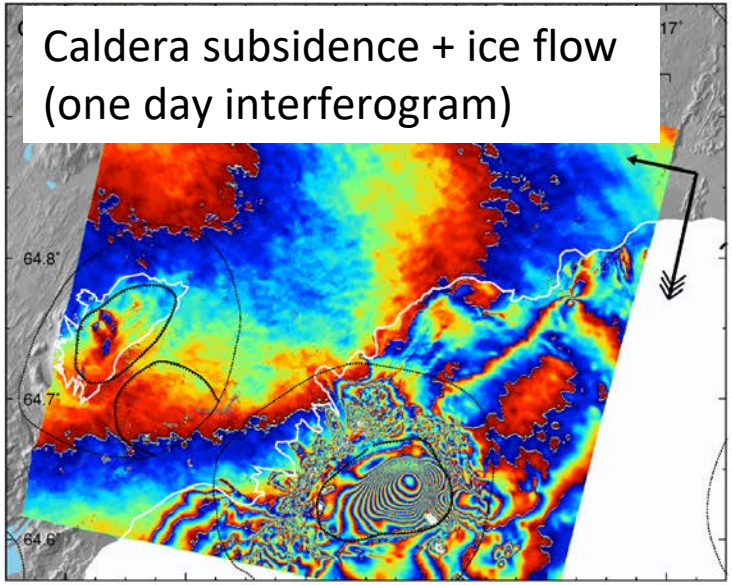
Stéphanie Dumont[1,2*], Freysteinn Sigmundsson[1], Michelle M. Parks[3], Vincent J. P. Drouin[1], Gro B. M. Pedersen[1], Ingibjörg Jónsdóttir[1], Ármann Höskuldsson[1], Andrew Hooper[4], Karsten Spaans[4], Marco Bagnardi[4], Magnús T. Gudmundsson[1], Sara Barsotti[5], Kristín Jónsdóttir[5], Thórdís Högnadóttir[1], Eyjólfur Magnússon[1], Ásta R. Hjartardóttir[1], Tobias Dürig[1,5], Cristian Rossi[6] and Björn Oddsson[7]

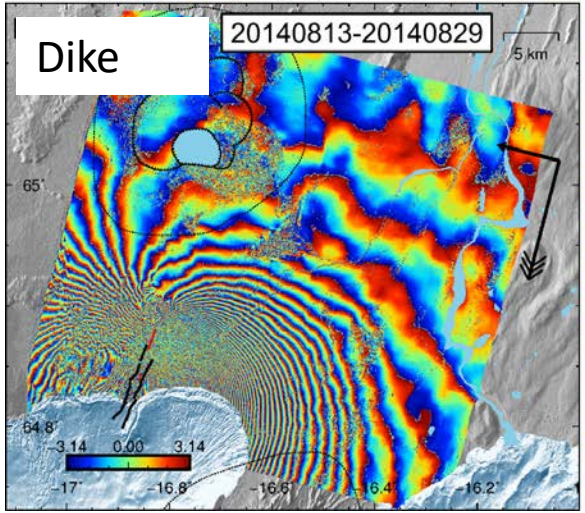
frontiers in Earth Science

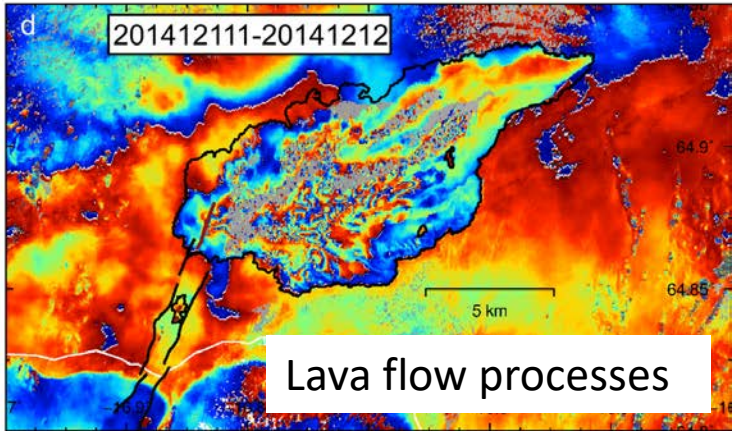
2018

Time-line showing the SAR satellite acquisitions over:
Bárðarbunga (upper)
Holuhraun (middle)
Aerial acquisitions (lower)
Unrest period and 6-months eruption









InSAR greatest hits in Iceland …

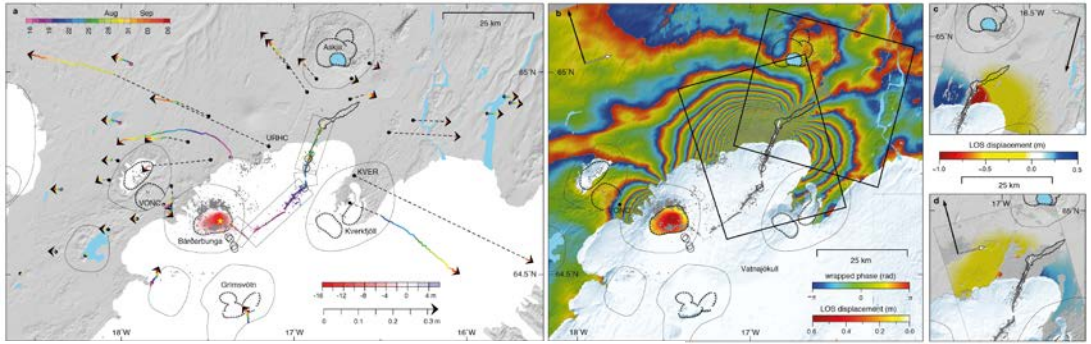
COSMO-SkyMed interferograms

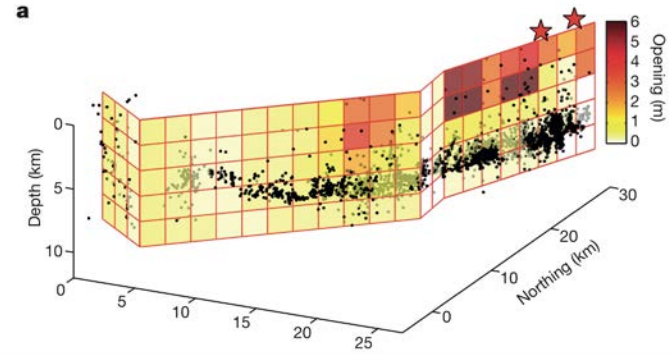
wrapped

1 fringe = 15.5 mm

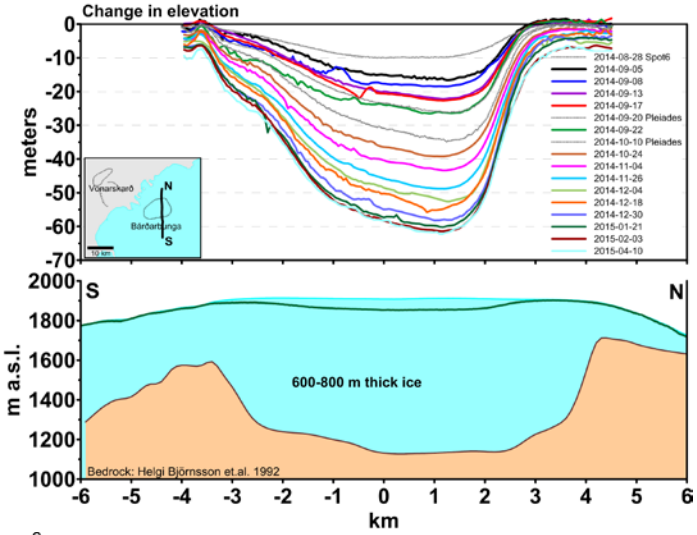
Dumont et al. 2018

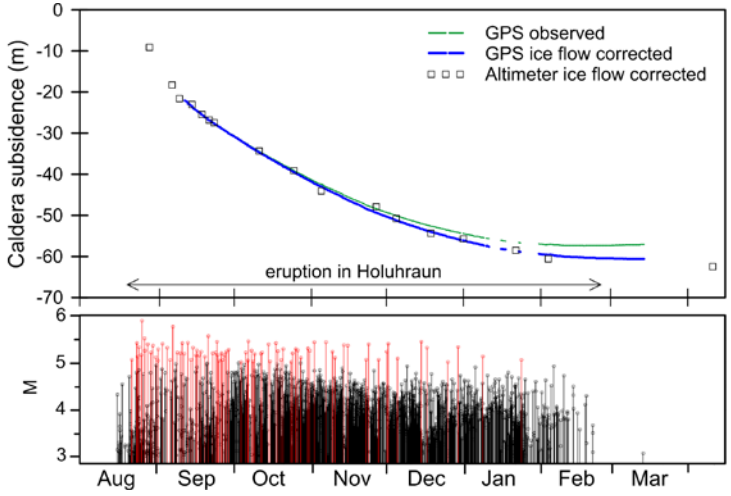
Bárðarbunga 2014-2015

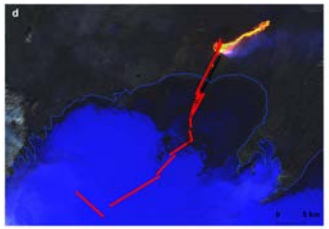




Lateral dike injection
Gradual caldera collapse
Major effusive eruption



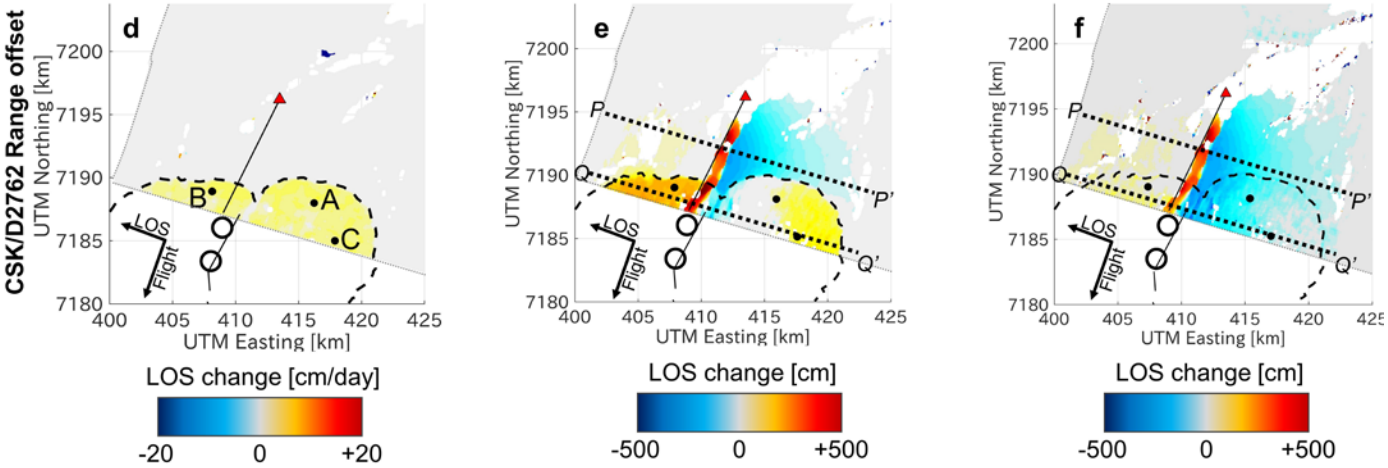




JGR Solid Earth

Icecap and subglacial crustal deformation inferred from SAR pixel tracking: the 2014 dike intrusion episode in the Bárðarbunga volcanic system, Iceland

Yuji Himematsu, Freysteinn Sigmundsson, Masato Furuya



Pixel tracking

Cross-correlation of features in amplitude images

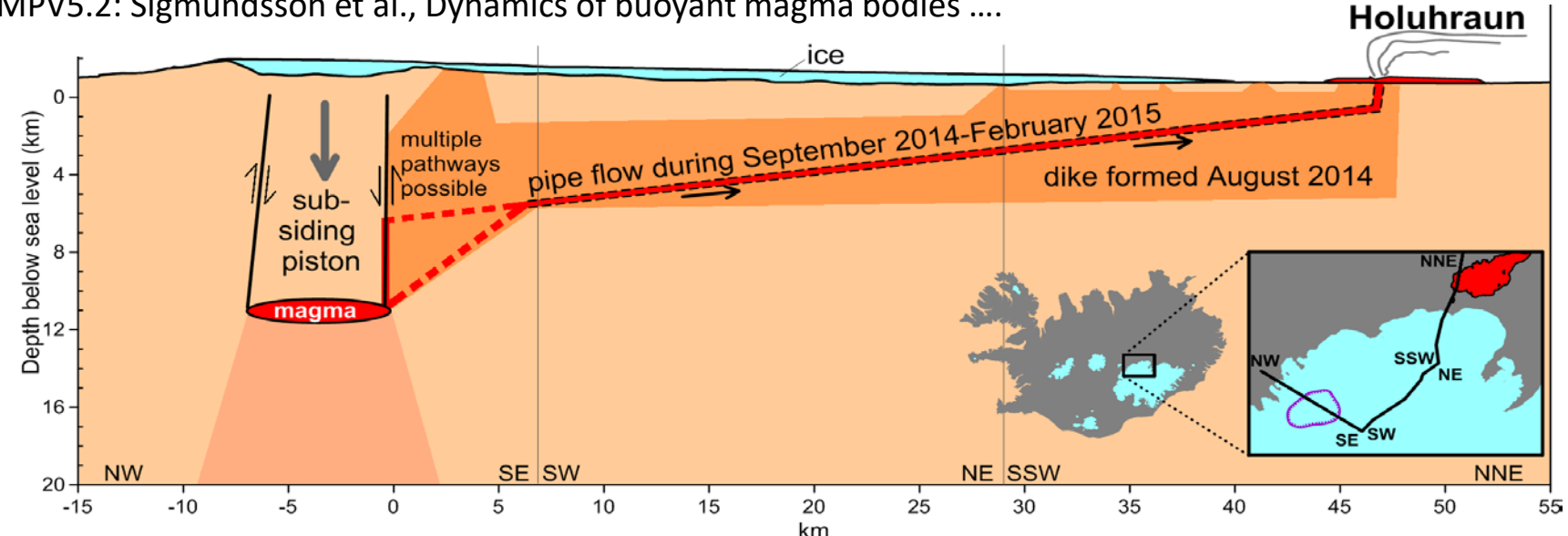
Selected Publications:

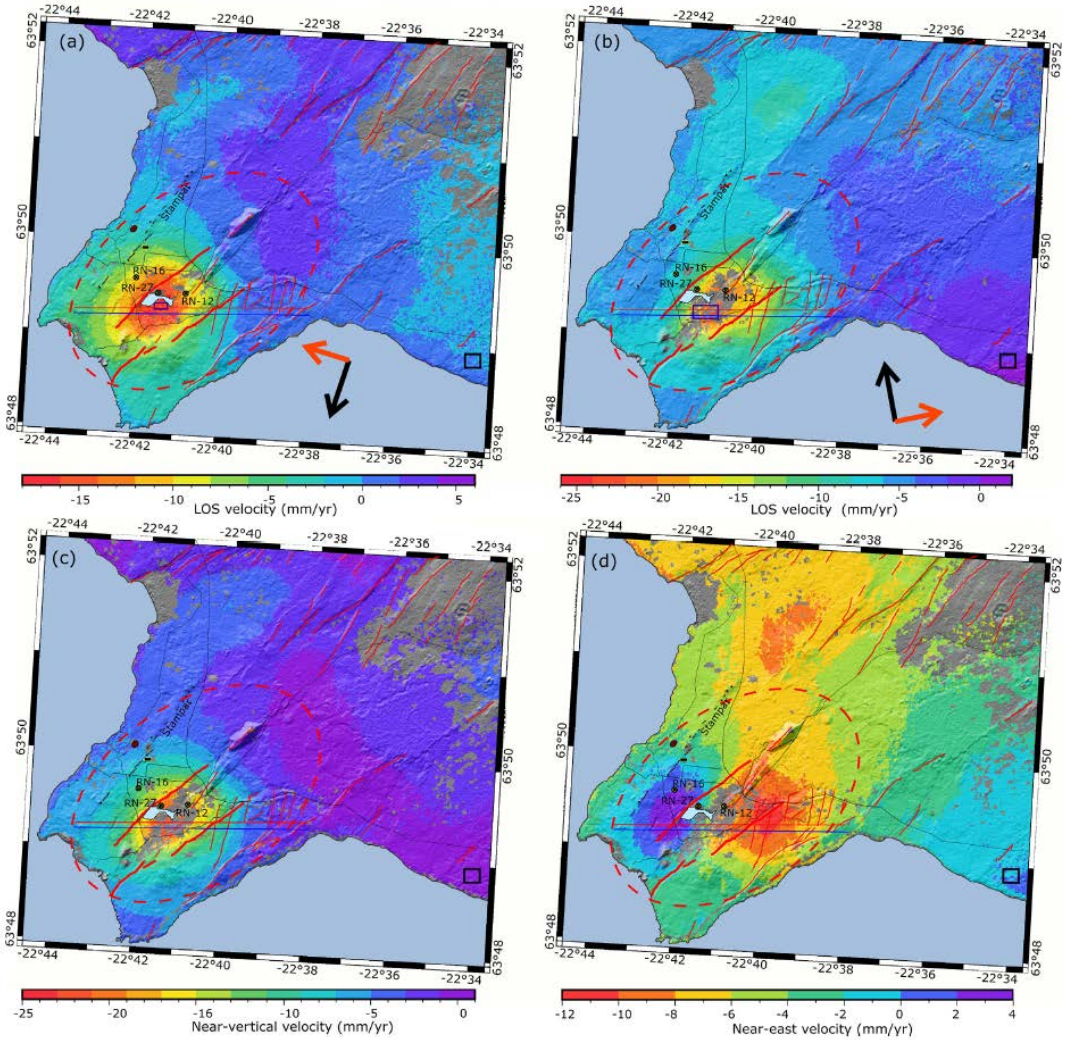
- Sigmundsson et al., Nature 2015
- Gudmundsson et al., Science 2016
- Ruch et al., 2016
- Pedersen et al., 2017
- Parks et al., EPSL 2017
- Dumont et al., 2018

More at EGU:

GMPV5.1: Li et al., Ground deformation following a caldera collapse ...

GMPV5.2: Sigmundsson et al., Dynamics of buoyant magma bodies ….





Geophysical Journal International

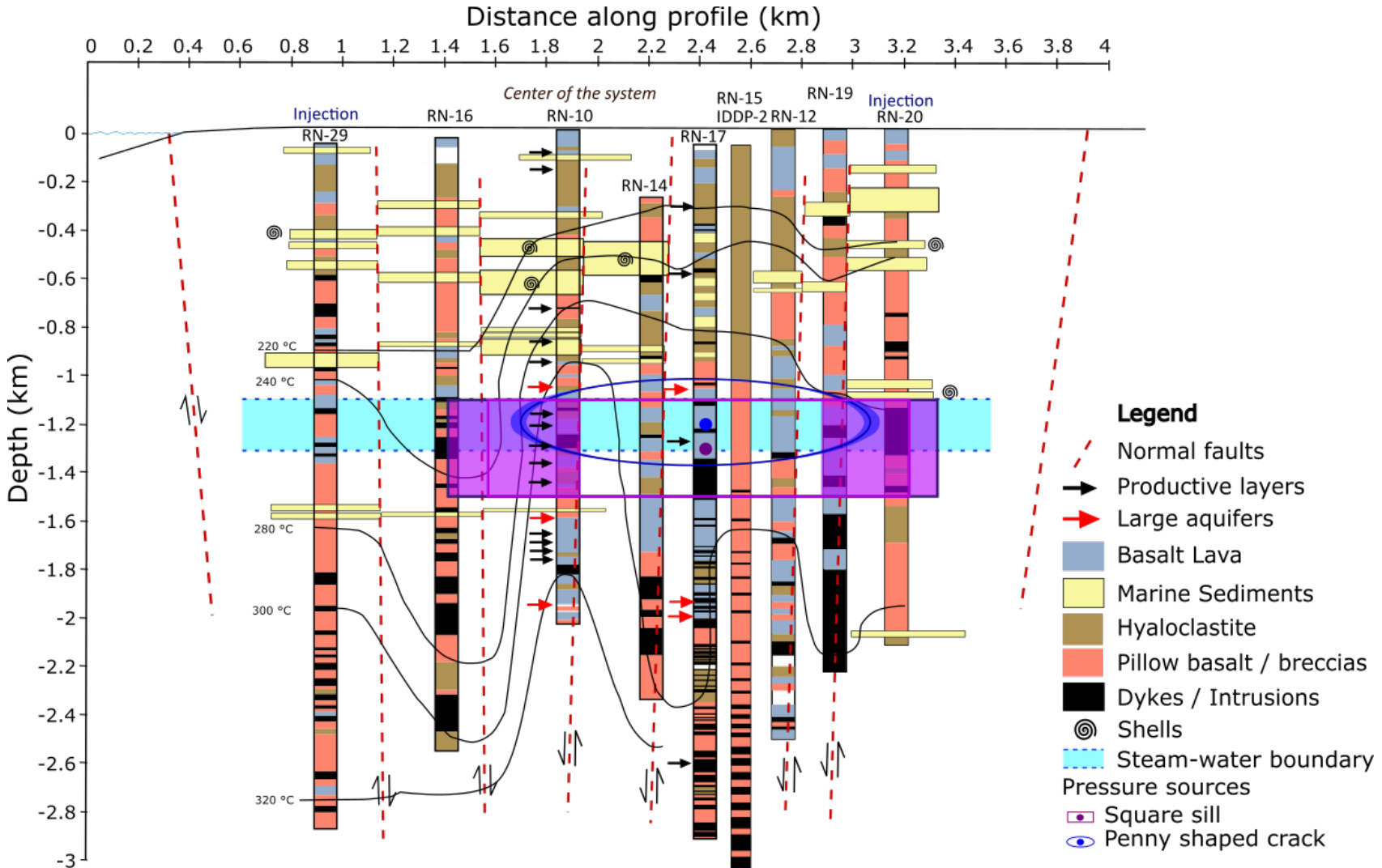
Geophys. J. Int. (2019) **216**, 2183–2212 doi: 10.1093/gji/g
Advance Access publication 2018 December 28
GJI Geodynamics and tectonics

Ground deformation due to steam cap processes at Reykjanes, SW-Iceland: effects of geothermal exploitation inferred from interferometric analysis of Sentinel-1 images 2015–2017

Mylene Receveur,[1] Freysteinn Sigmundsson,[1] Vincent Drouin[1,2] and Michelle Parks[3]

Sentinel-1 InSAR time series analysis
Average velocity maps (mm/yr)

a) LOS velocities for ascending Track 16
b) LOS velocities for descending Track 155
c) Estimated near-vertical velocity
d) Estimated near-east horizontal velocity


Distance along profile (km)
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3 3.2 3.4 3.6 3.8 4
Center of the system
Injection
RN-29
RN-16
RN-10
RN-14
RN-17
RN-15
IDDP-2
RN-12
RN-19
Injection
RN-20
Depth (km)
0 -0.2 -0.4 -0.6 -0.8 -1 -1.2 -1.4 -1.6 -1.8 -2 -2.2 -2.4 -2.6 -2.8 -3
220 °C
240 °C
280 °C
300 °C
320 °C
Legend
Normal faults
Productive layers
Large aquifers
Basalt Lava
Marine Sediments
Hyaloclastite
Pillow basalt / breccias
Dykes / Intrusions
Shells
Steam-water boundary
Pressure sources
Square sill
Penny shaped crack

MOOC
massive open online course.

edX.org

search for: volcano

UNIVERSITY OF ICELAND
norden NordVulk
Icelandic Met Office
UNIVERSITY OF LEEDS
USGS science for a changing world
EUROVOLC
GSNL GEO Geohazards Supersites and Natural Laboratories
GEO GROUP ON EARTH OBSERVATIONS
CEOS
FUTUREVOLC
UNAVCO

MOOC (massive open online) course, available for all, on volcano monitoring and magma movements, offered by University of Iceland through its participation in edX.

https://www.edx.org/course/monitoring-volcanoes-and-magma-movements

Number of registered learners in initial instructor-paced course and the following self-paced version: >2000 (total)

Youtube channel for EdX course on volcano monitoring and magma movements:

https://www.youtube.com/playlist?list=PL_WaJm0UADkDMxkV5HKyhJx9a6ca2hDi6

Icelandic Volcanoes Supersite

- New scientific results + societal benefits (including education)
- Results communicated to Iceland Civil Protection
- Unrest evaluated: Bárðarbunga / Öræfajökull
- One day COSMO-SkyMed interferograms
- New understanding of magma movements
- Geothermal processes evaluated
- Continued new results / input to hazard evaluation