The 2014-15 Bárðarbunga dyke intrusion and caldera collapse

UNIVERSITY OF ICELAND
INSTITUTE OF EARTH SCIENCES

GNS SCIENCE TE PŪ AO

Icelandic Met Office

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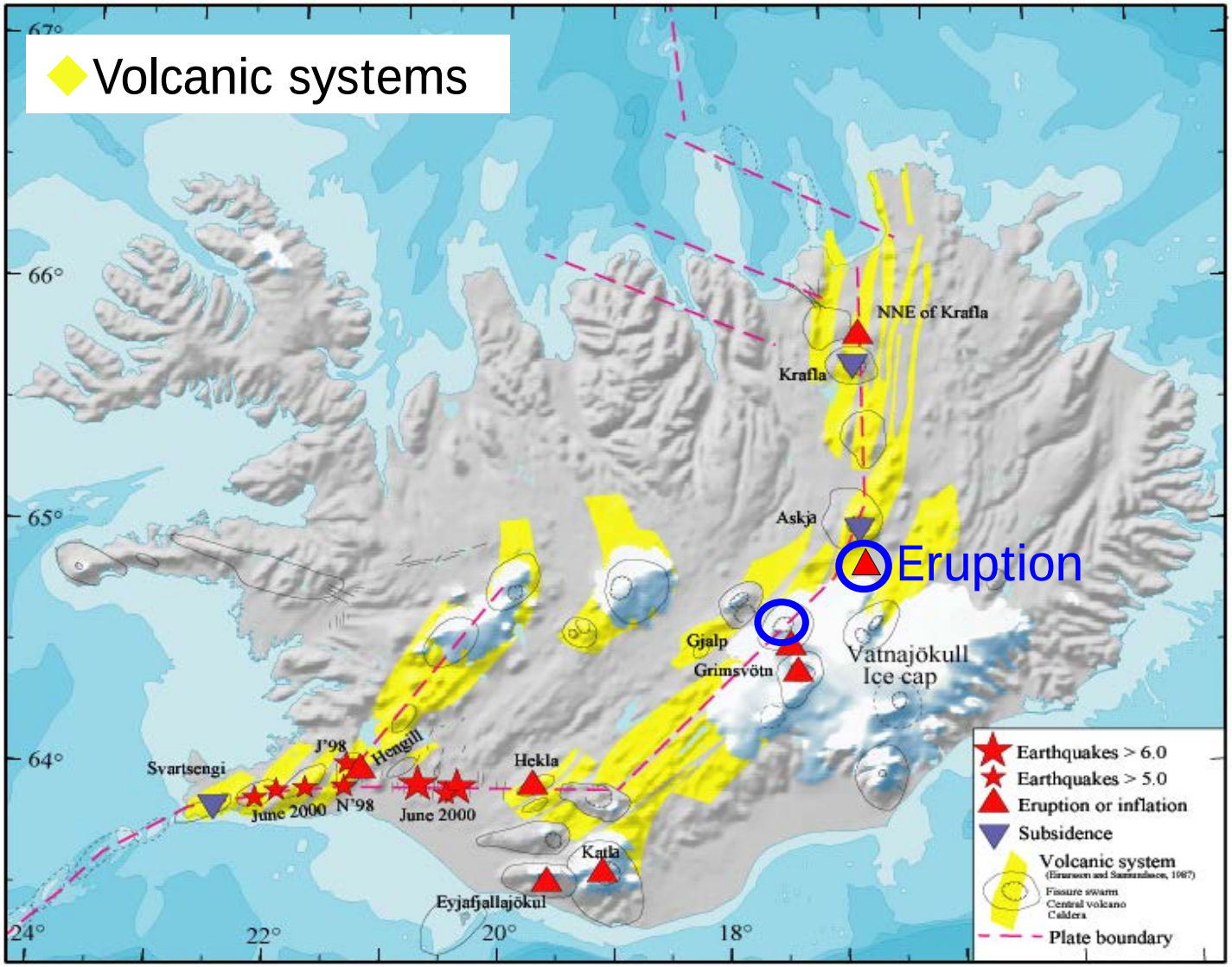
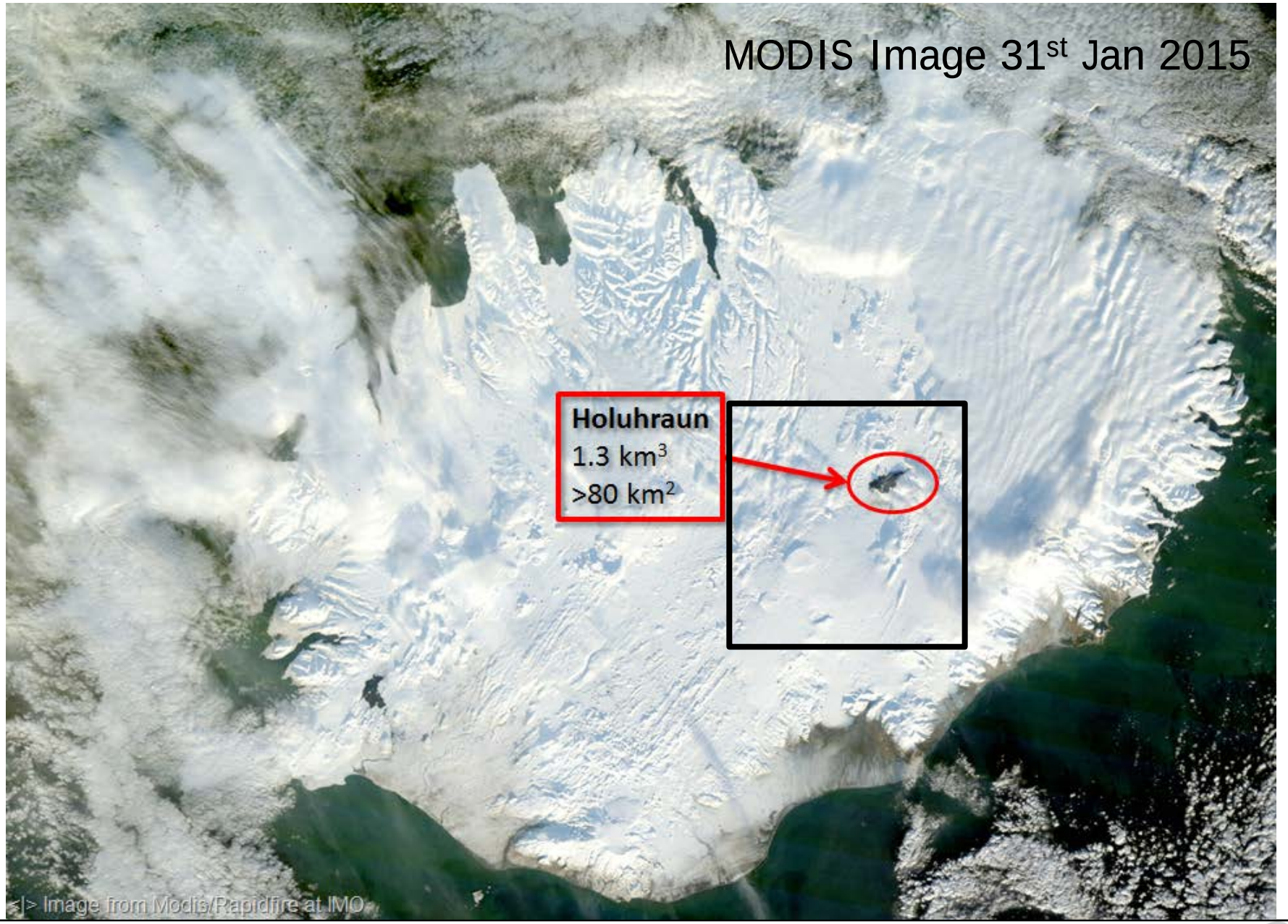
Bárðarbunga location

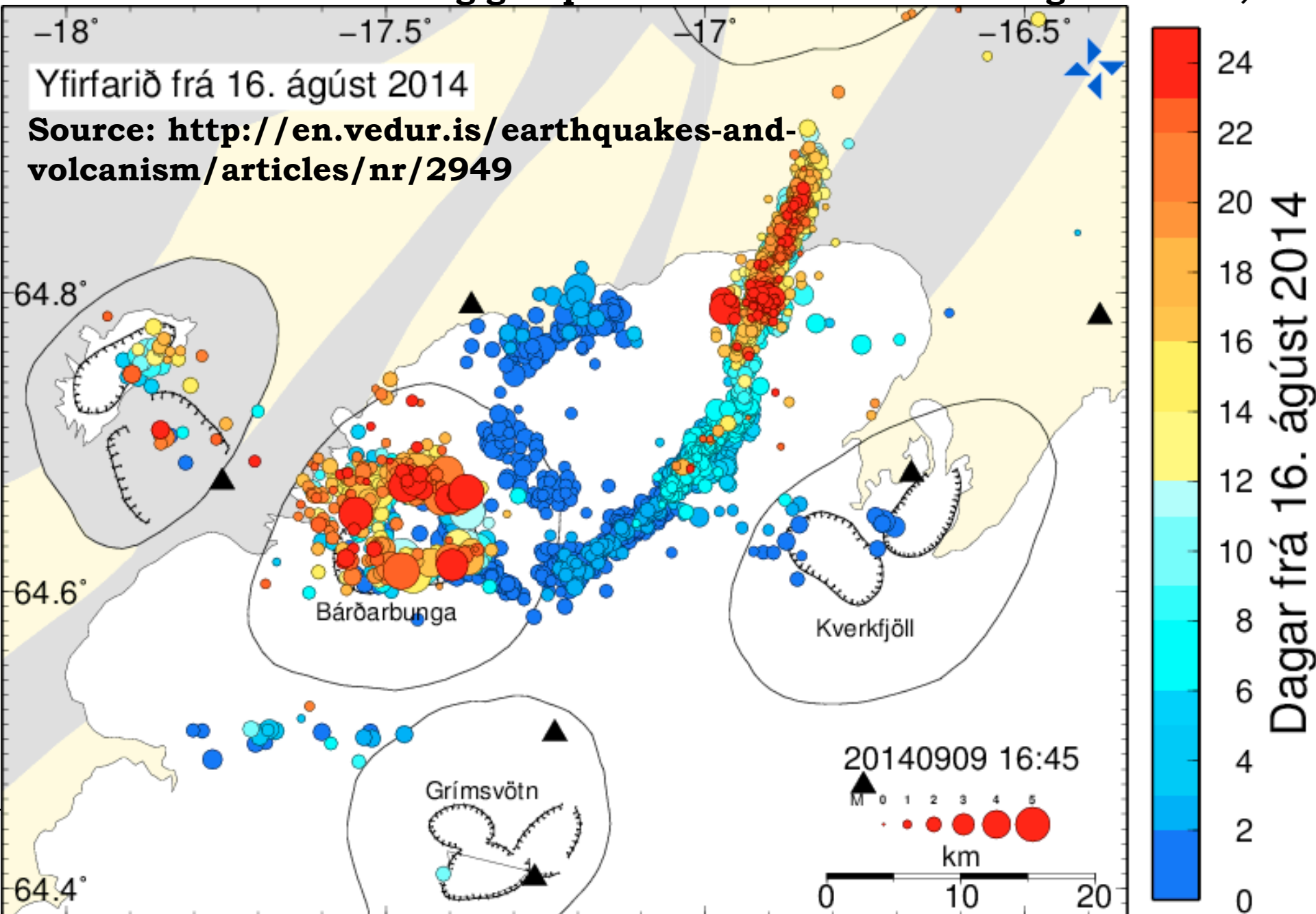


Bárðarbunga, 2014-2015

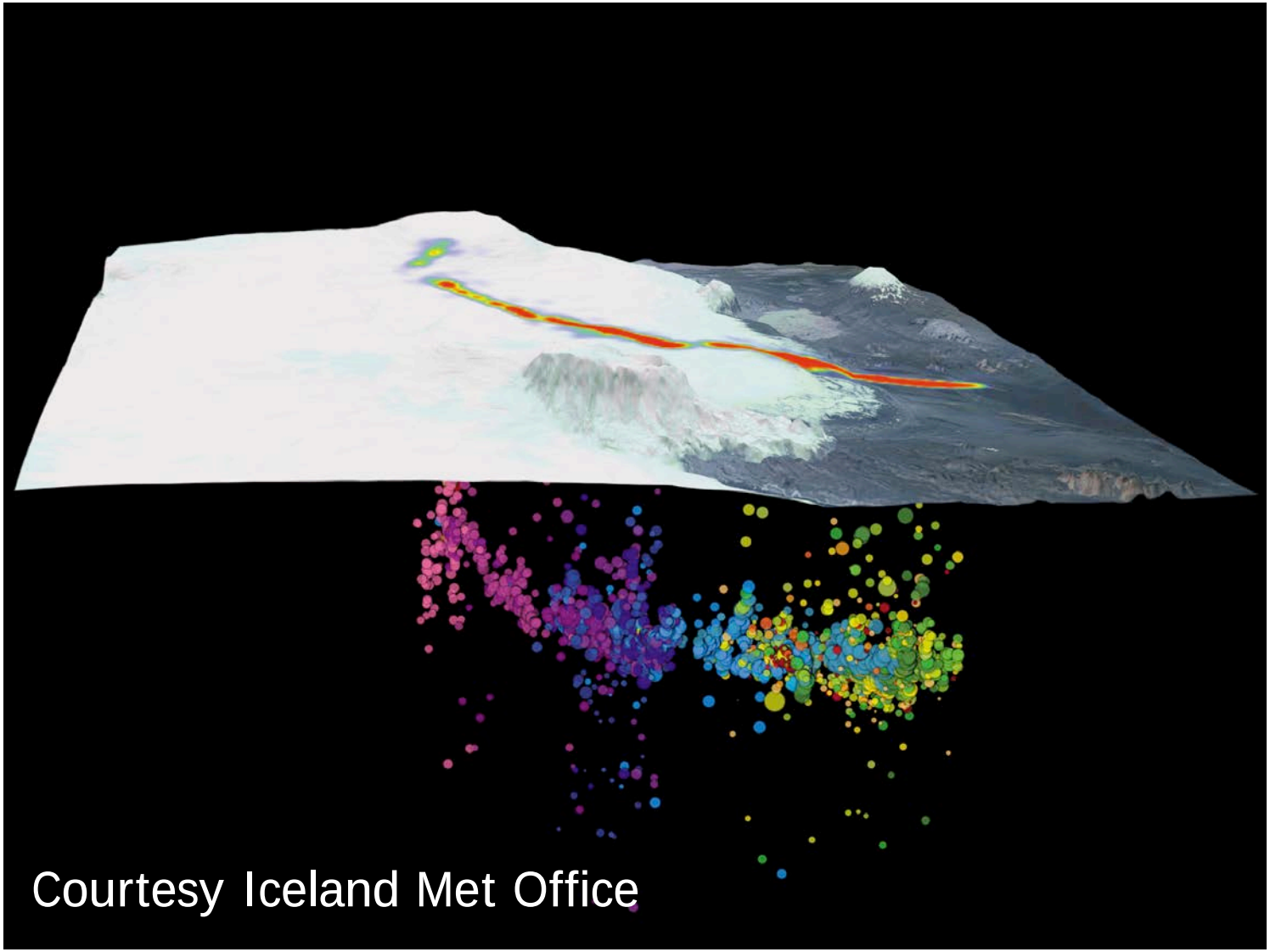
MODIS Image 31st Jan 2015



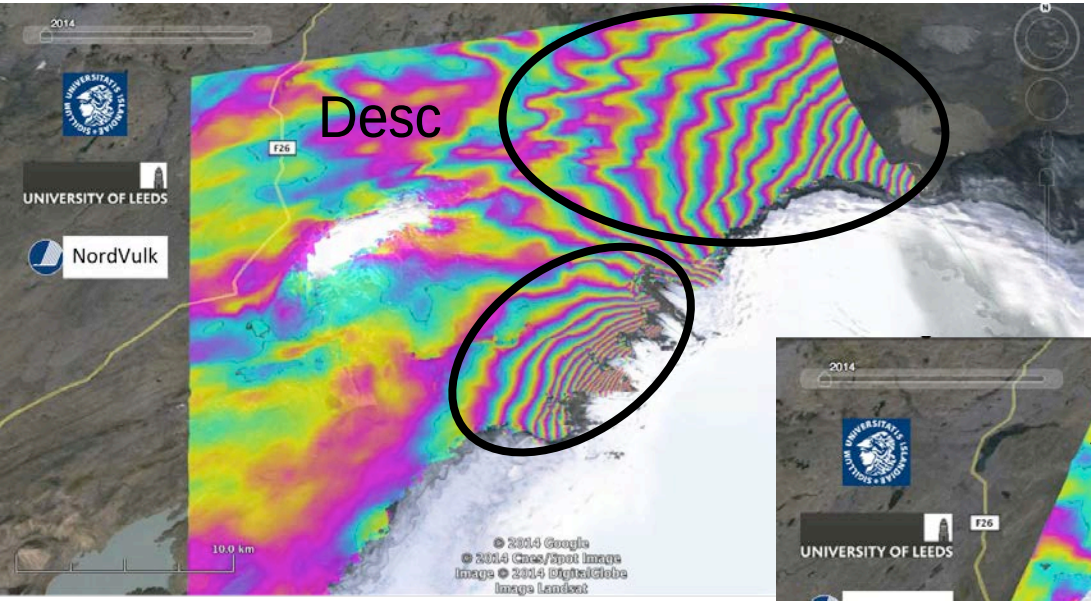
Seismicity since the 16th August. Preliminary data analysed by the SIL seismic monitoring group of the Icelandic Meteorological Office, as

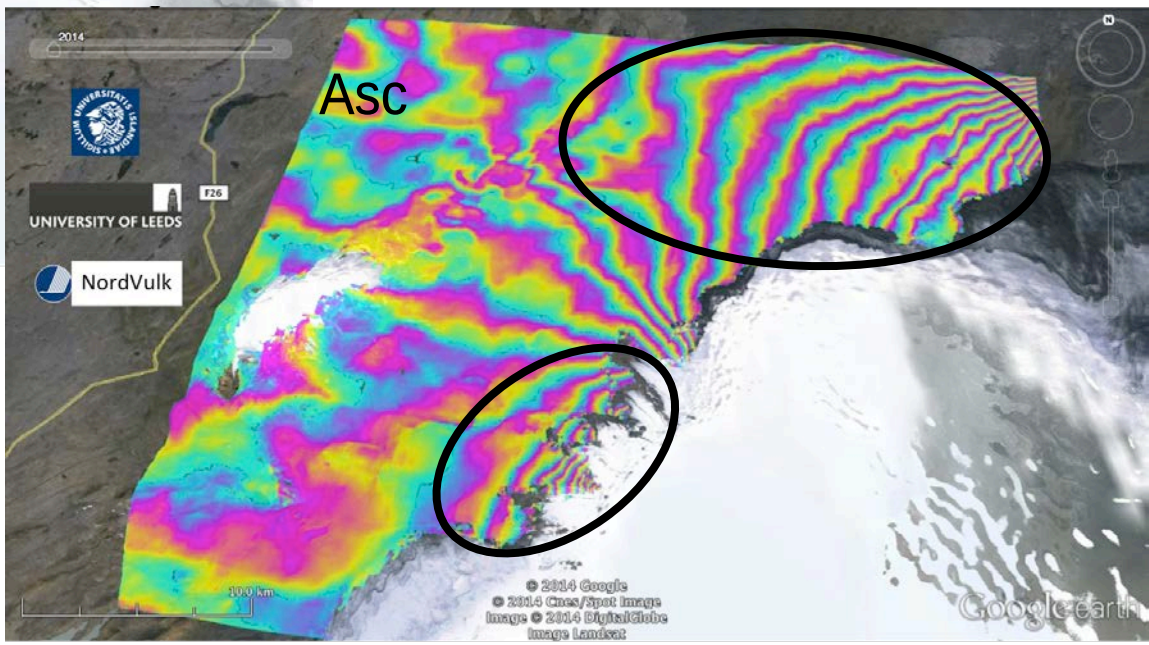


Seismicity Depth



CSK interferograms to 26/27 Aug

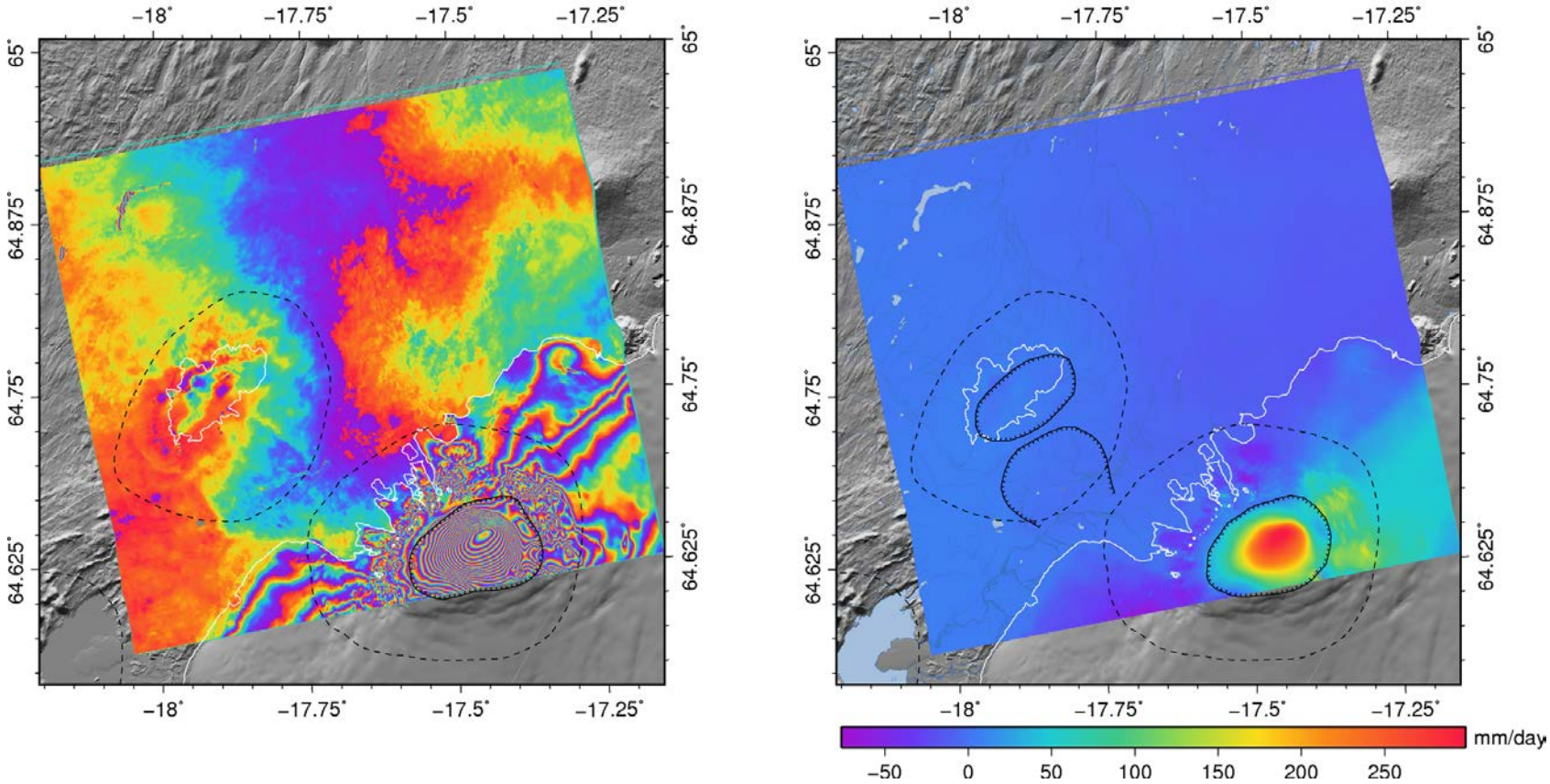




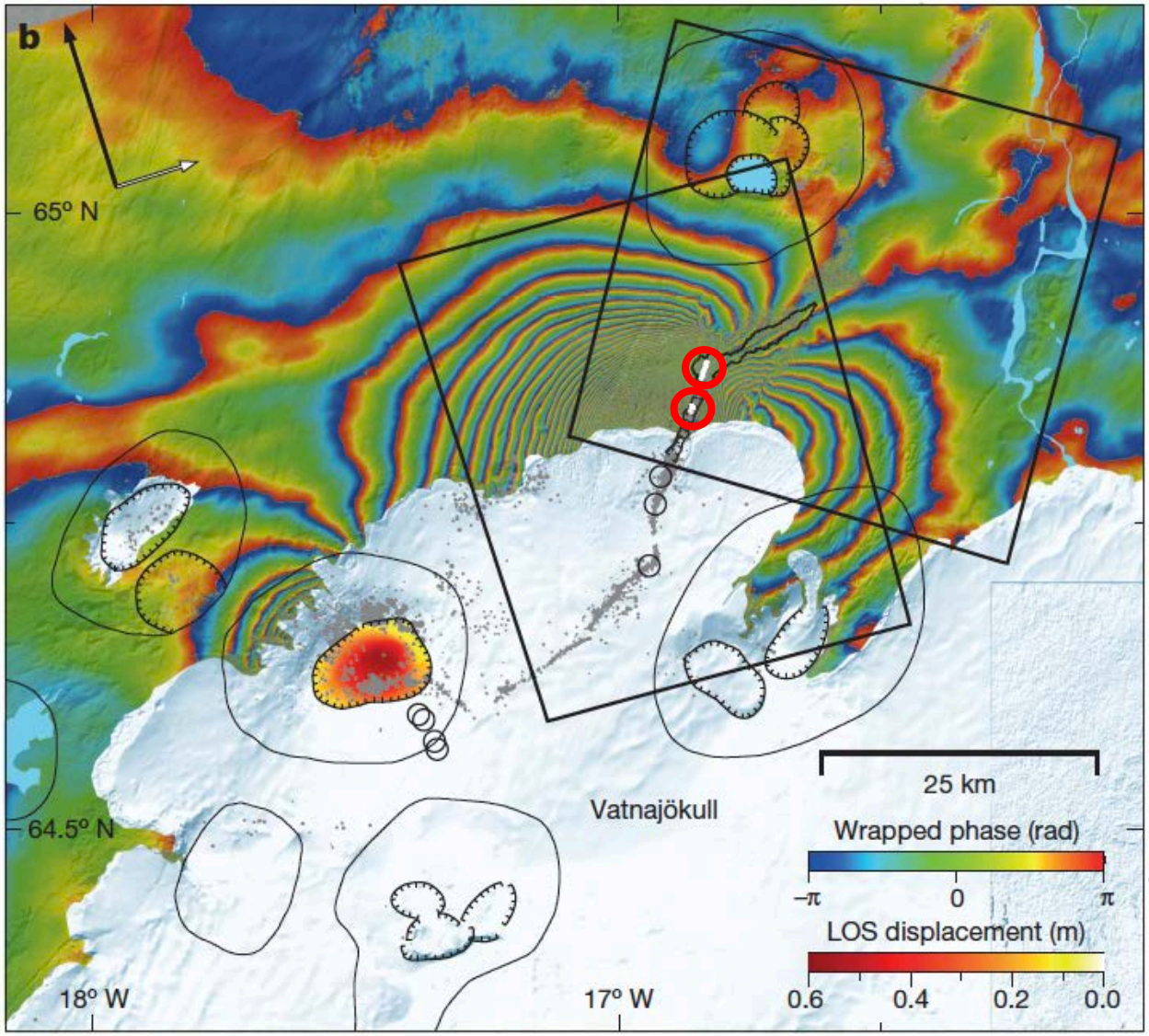
Down and towards caldera

Away from propagating dyke

Example 1-day CSK interferogram



Deformation and seismicity up to eruption



2 weeks

1 day

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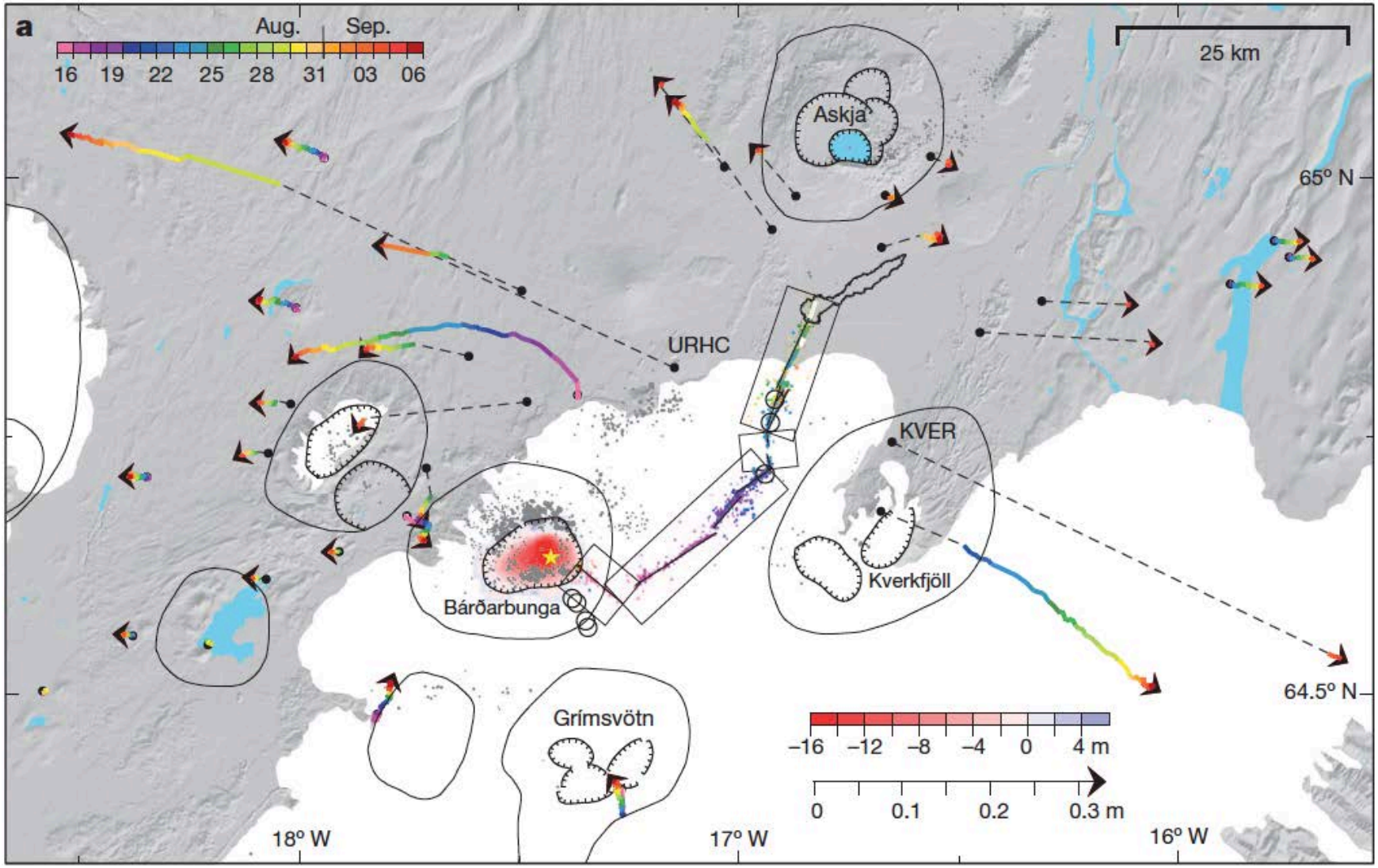
GPS Leading to eruption



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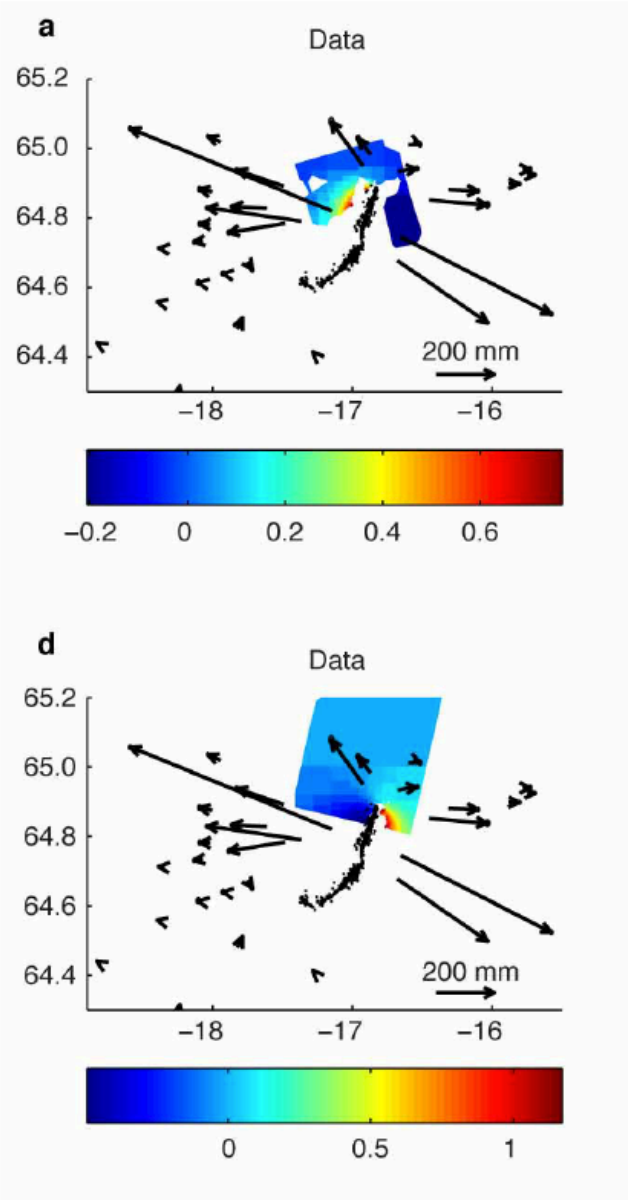
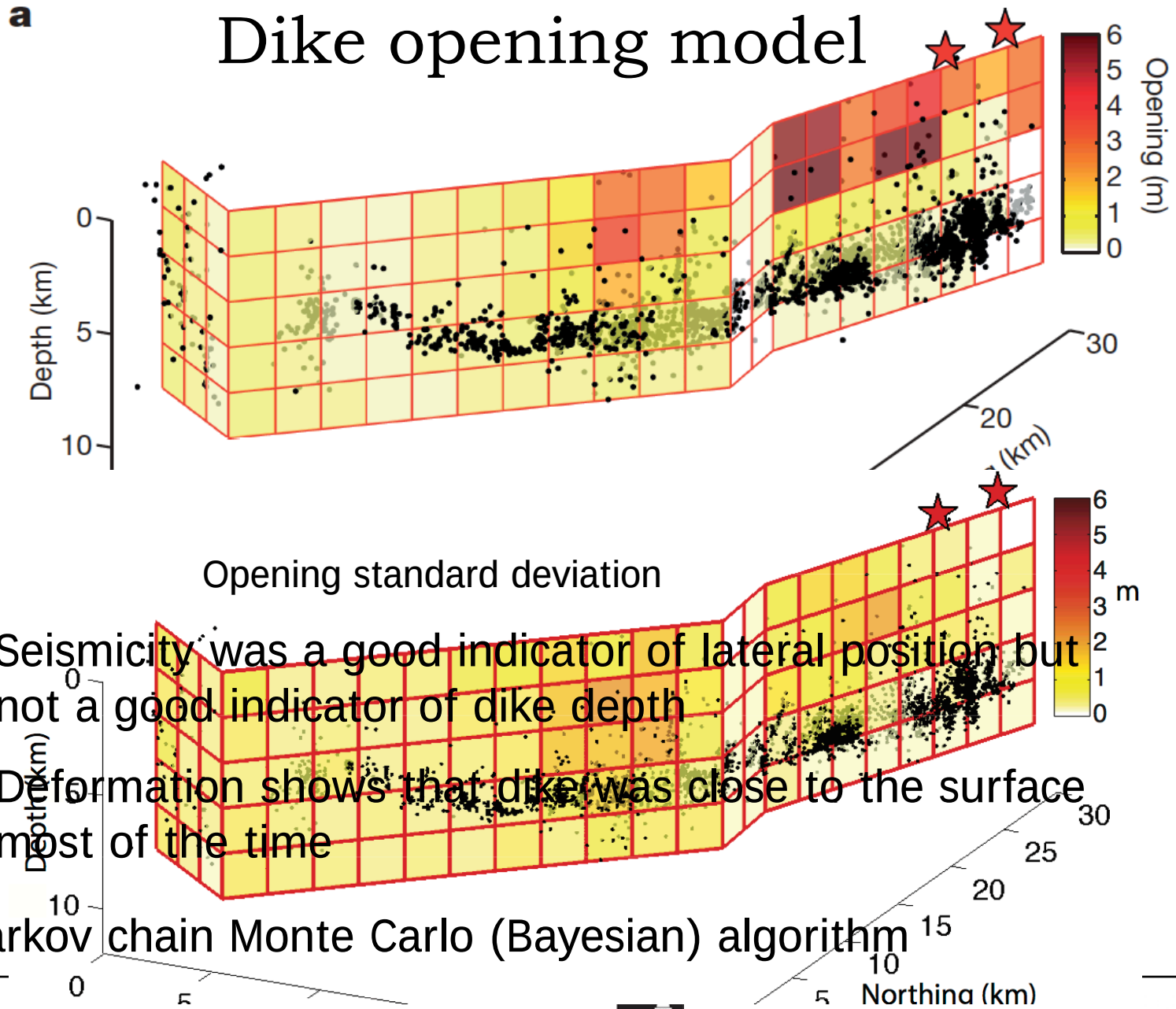
Deformation model for whole intrusion



Dike opening model



- Seismicity was a good indicator of lateral position but not a good indicator of dike depth
- Deformation shows that dike was close to the surface most of the time

Markov chain Monte Carlo (Bayesian) algorithm

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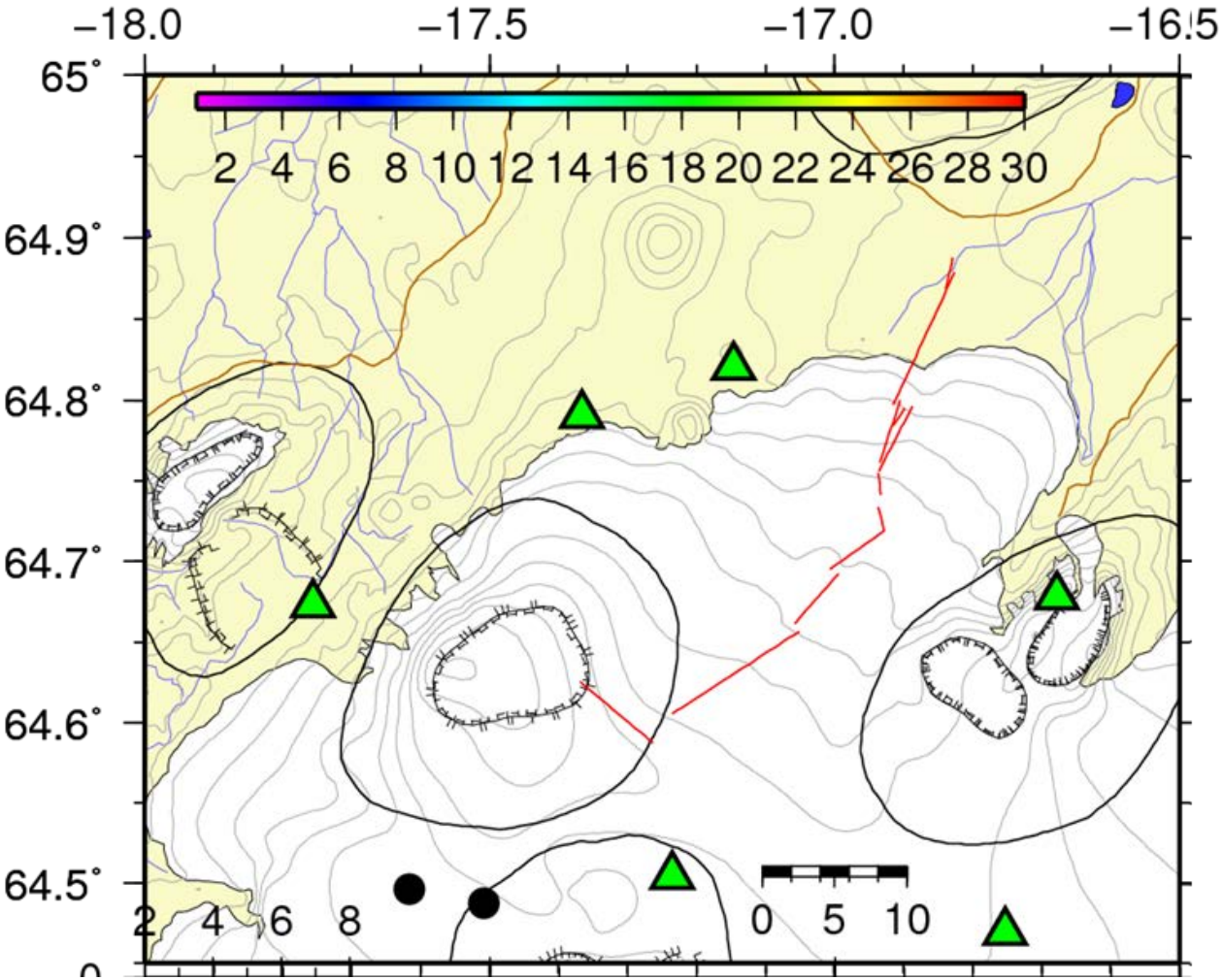
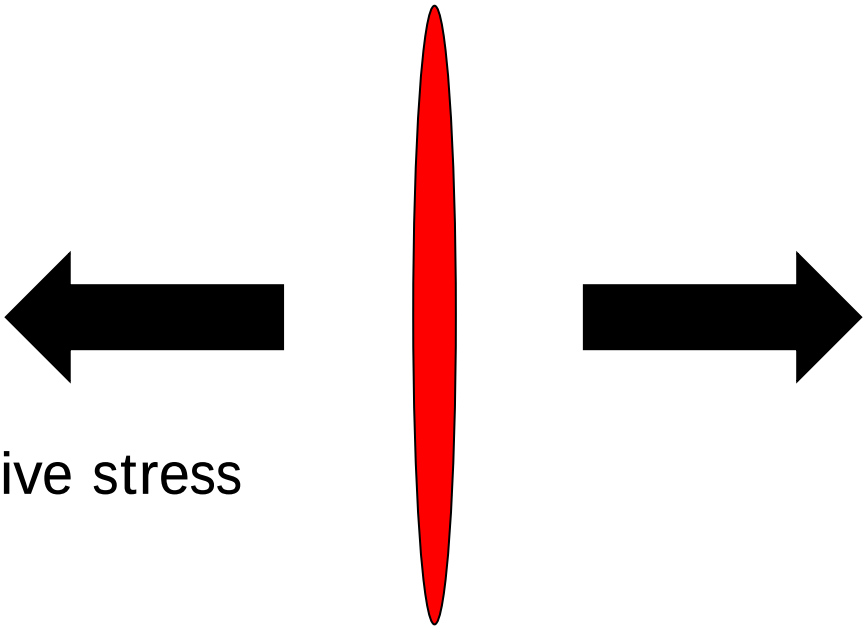
What dictates propagation direction?



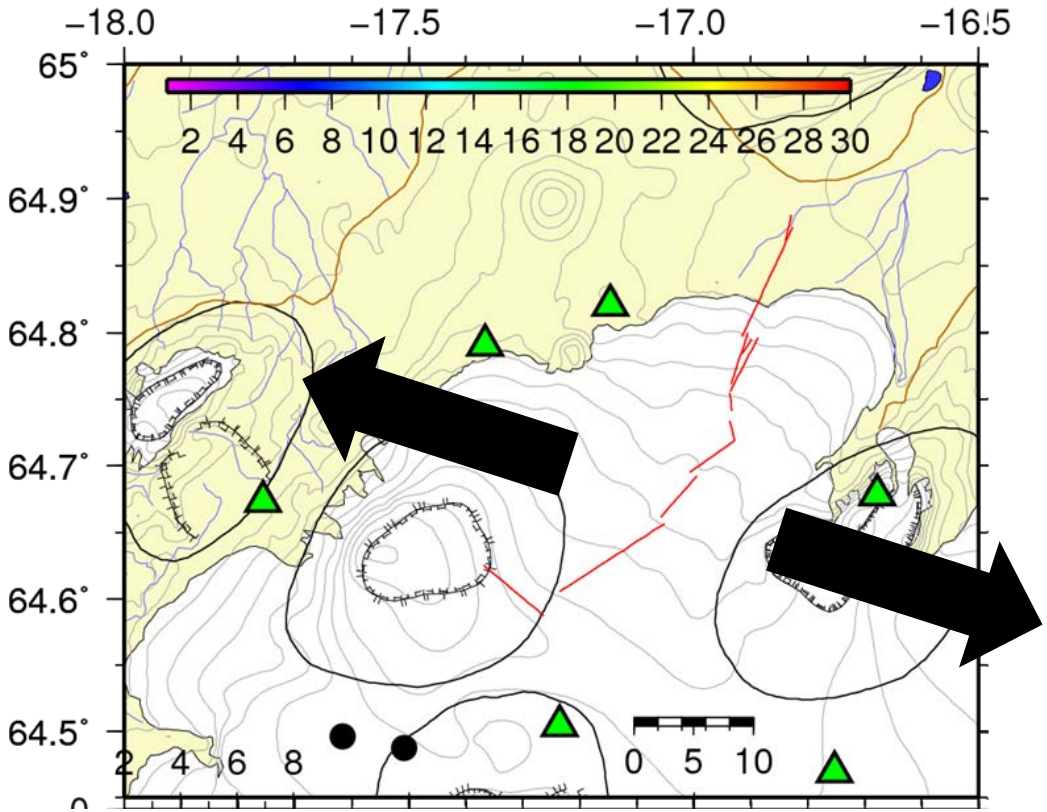
If dyke orientation controlled by stress



Least compressive stress

(Viewed from above or in profile)

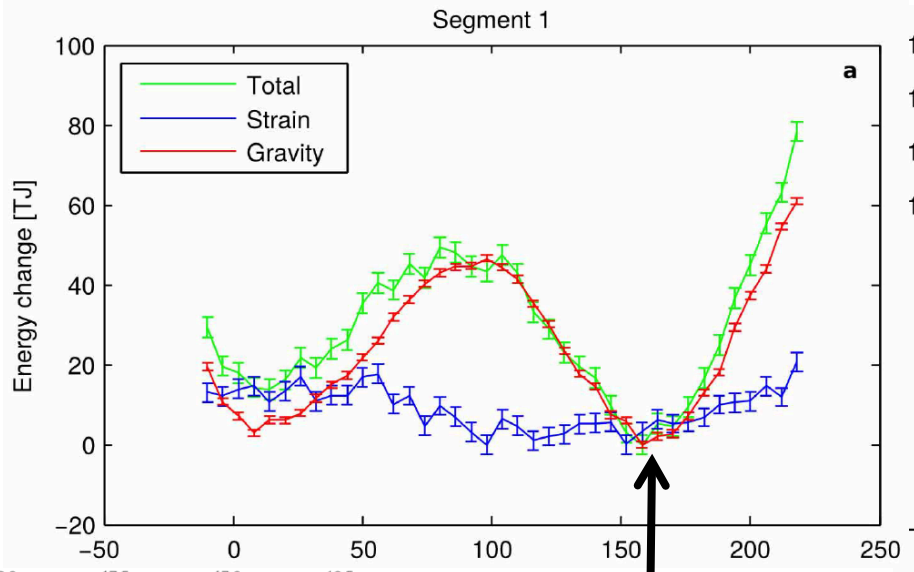
What dictates propagation direction?

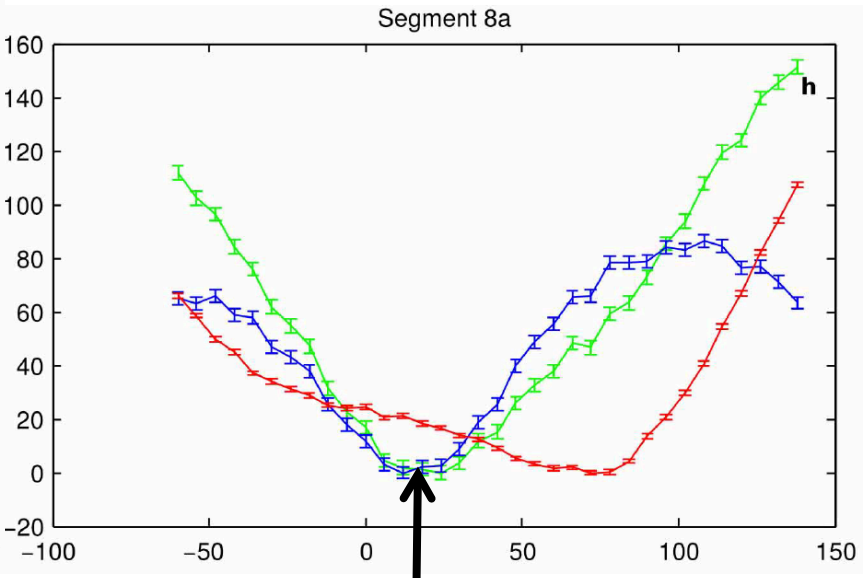


- Stress cannot be only control
- Need to consider total potential energy change

Propagation direction

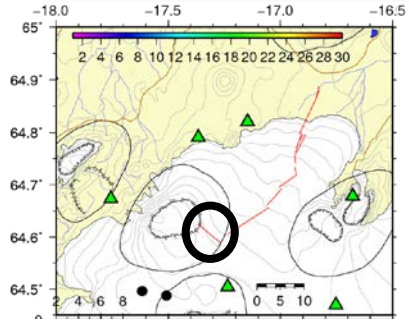
Total potential energy change





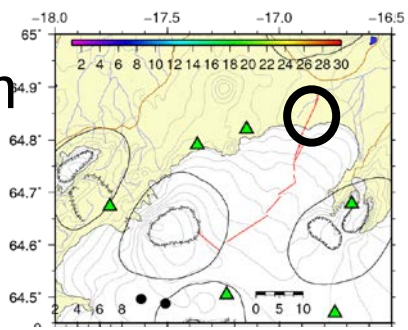
Strike

Minimum



Strike

Minimum



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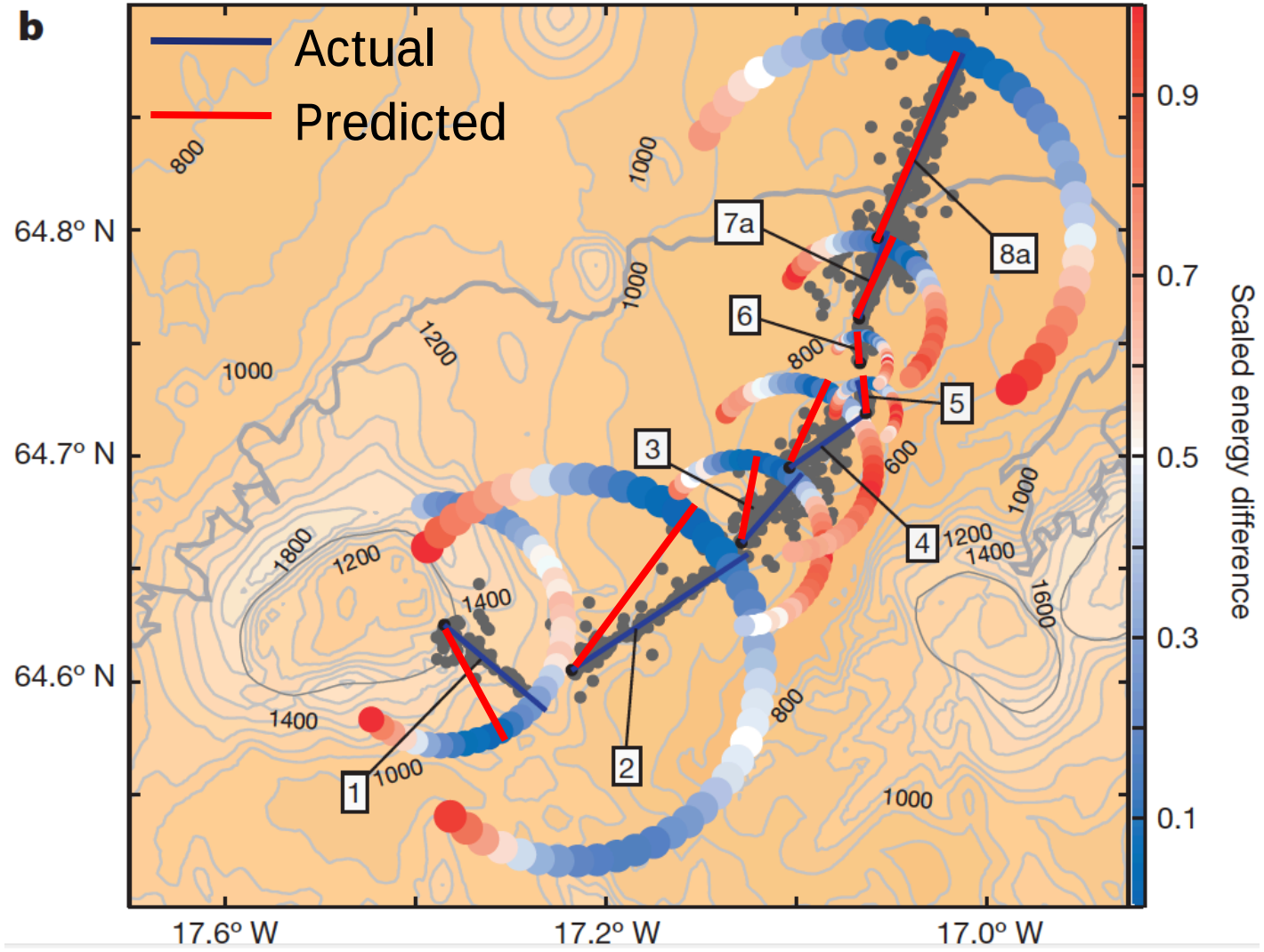
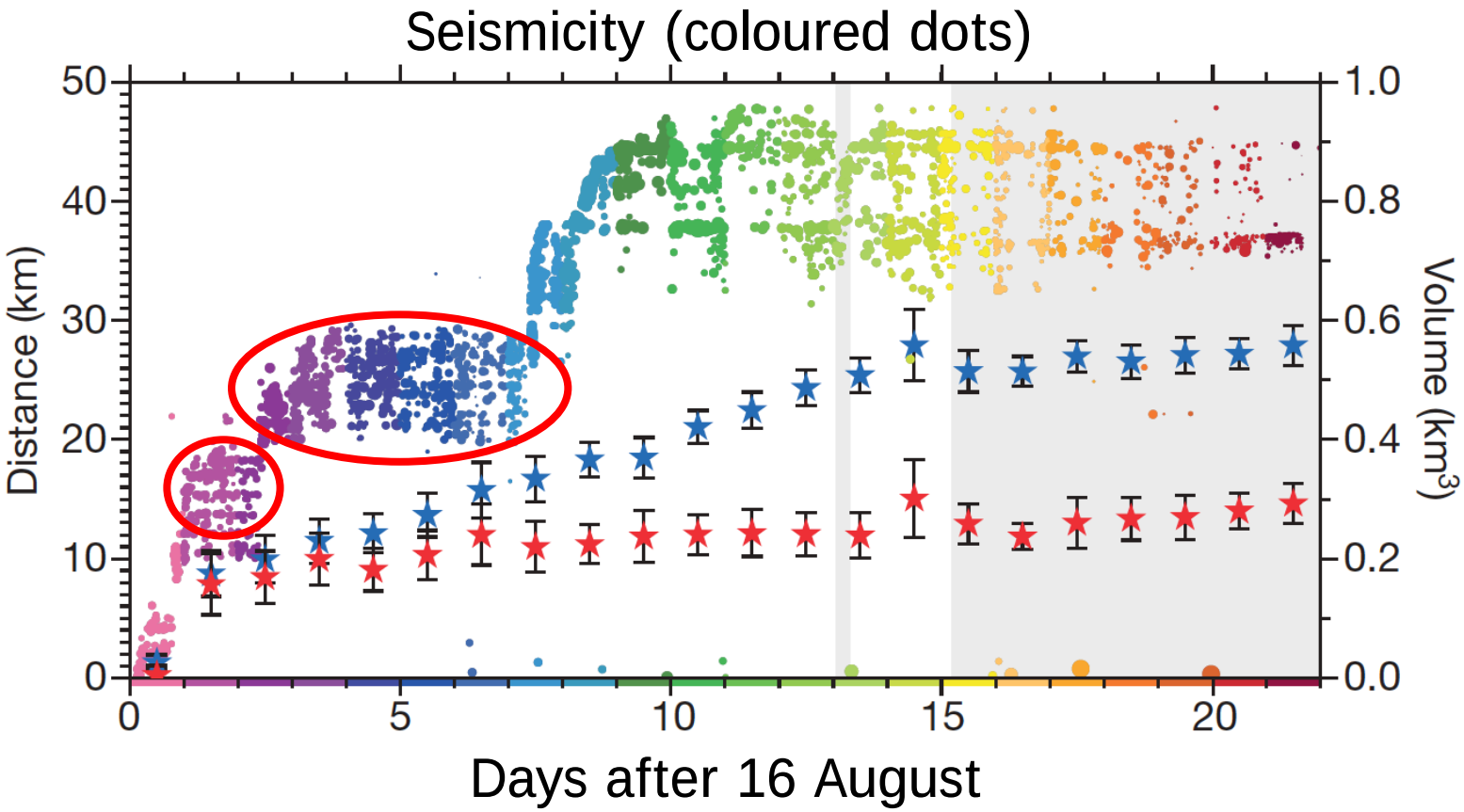
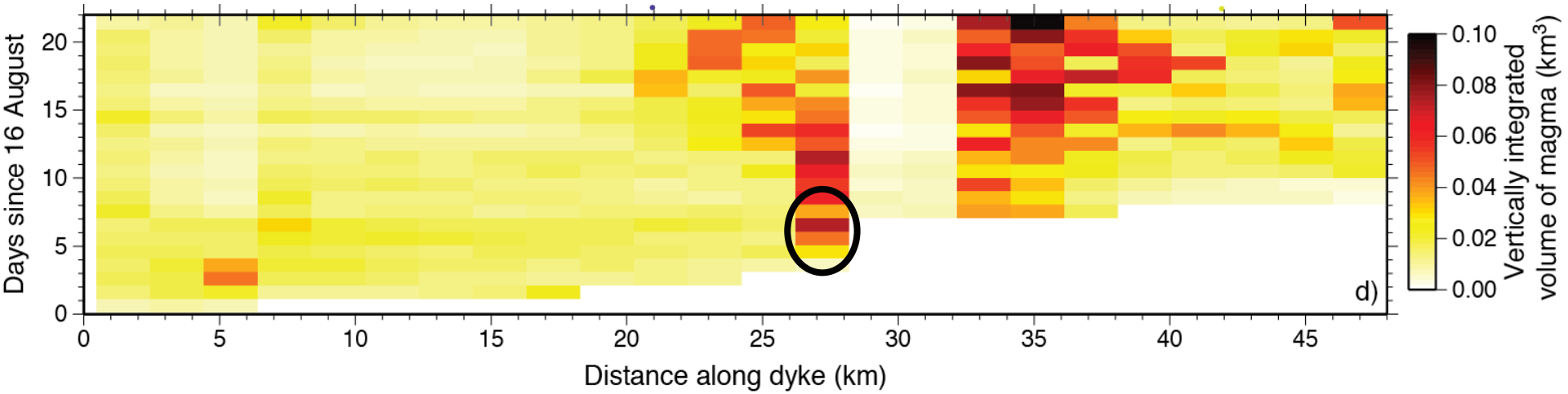
Predicted propagation versus actual



What about timing?

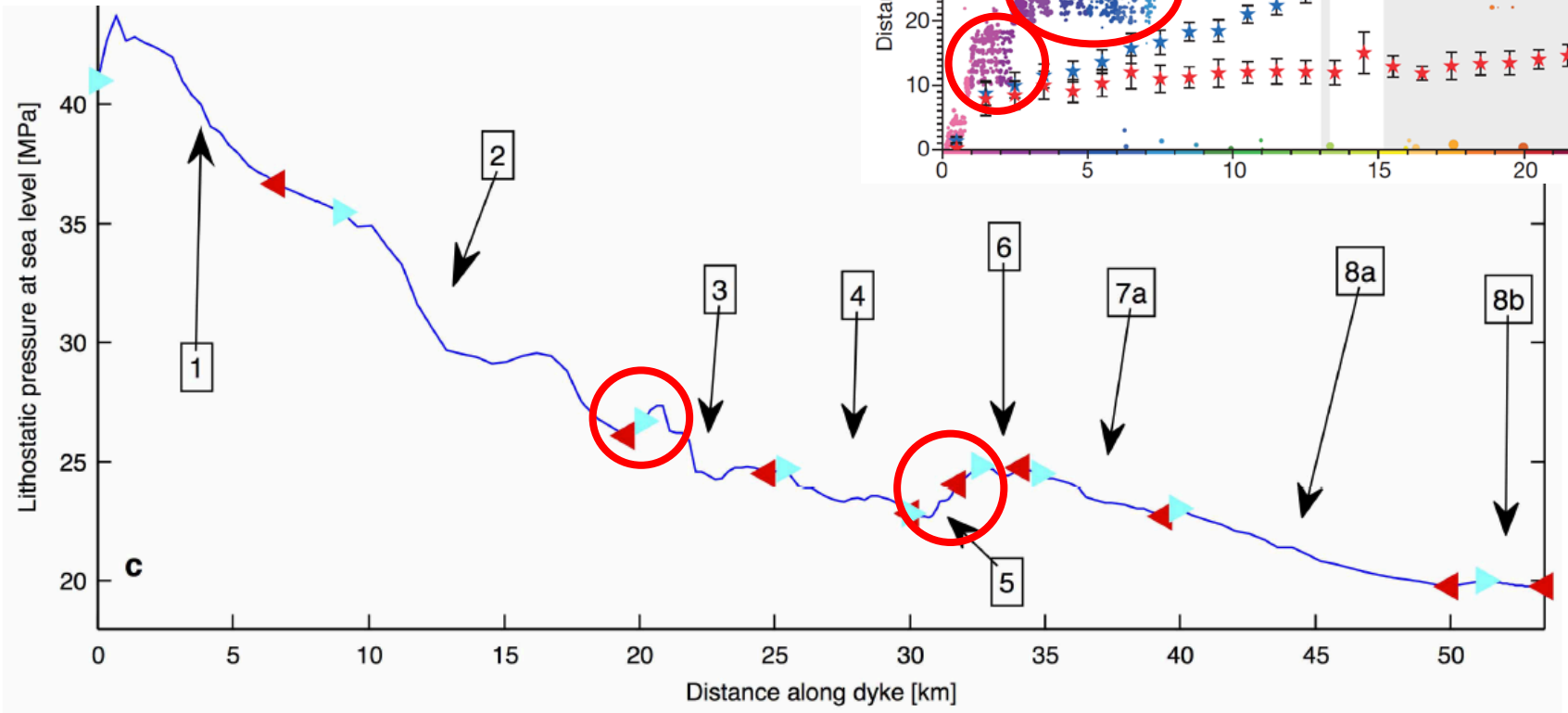


Dike volume with time



- Pressure builds before propagation resumes

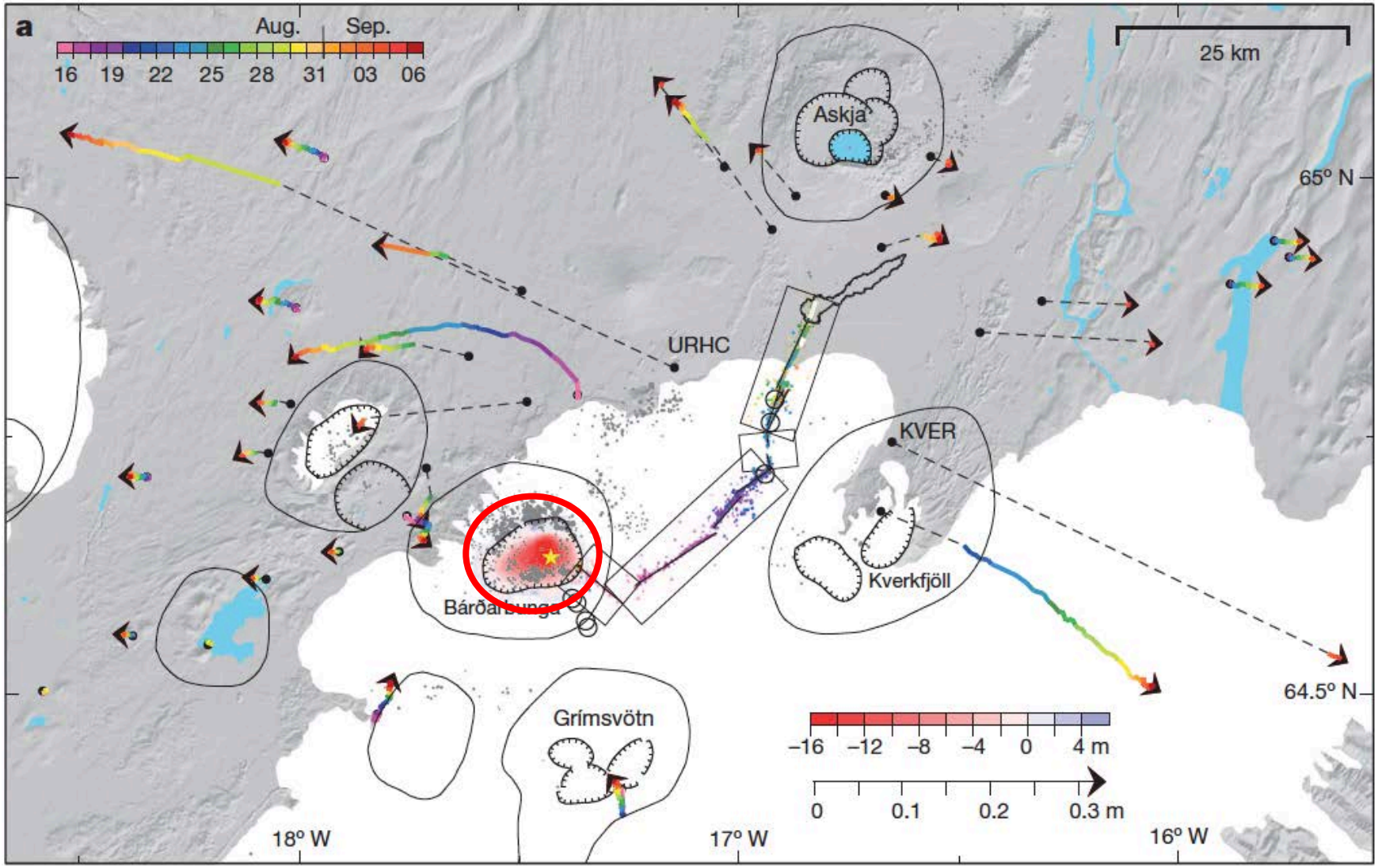
Lithostatic pressure along dike



- Forecasting propagation direction and timing seems possible
- Also potential for forecasting eruption
- Sigmundsson, Hooper, Hreinsdottir et al., Nature 2014

What about the eruption evolution?

Overview of events



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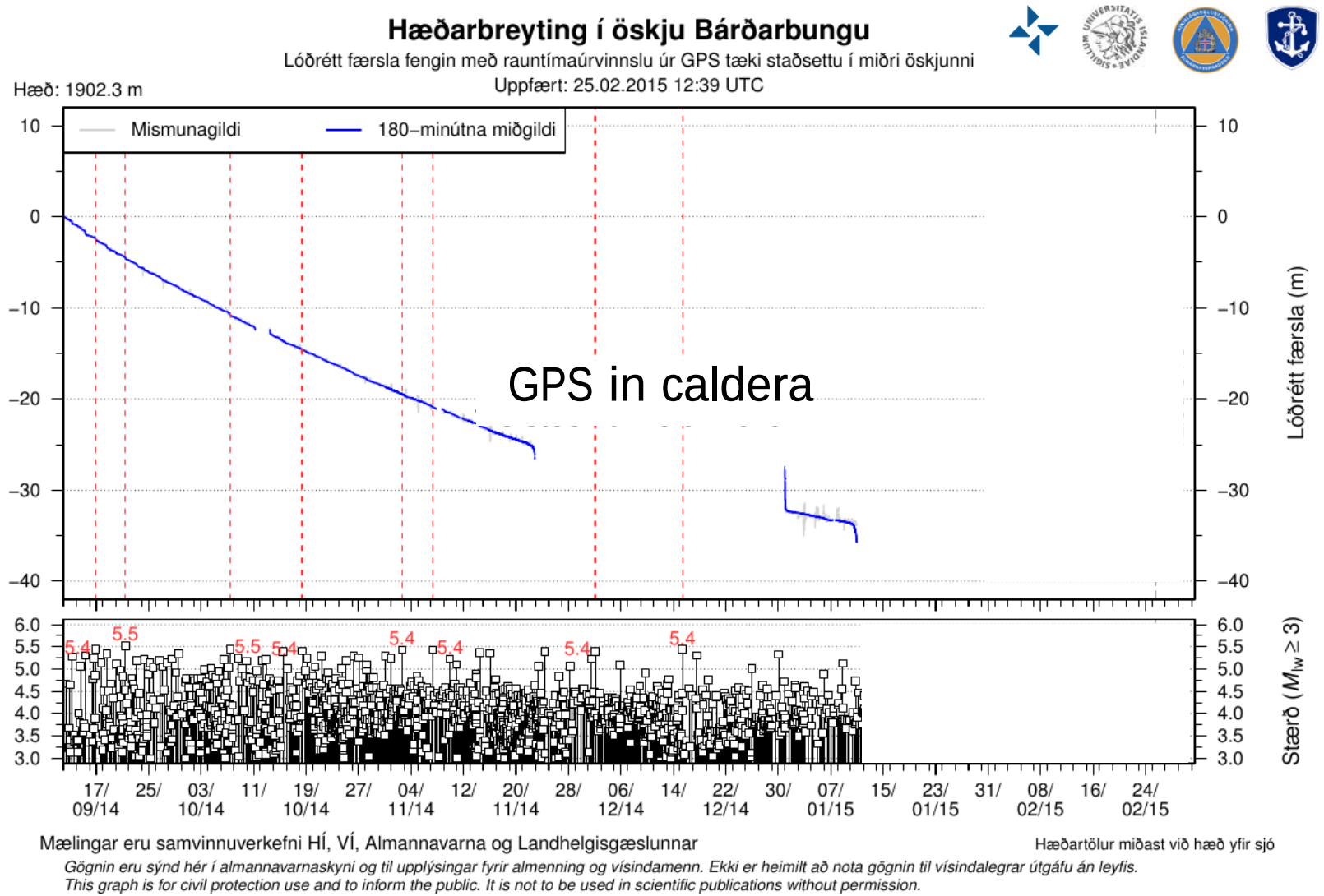
Caldera subsidence to 11th Jan



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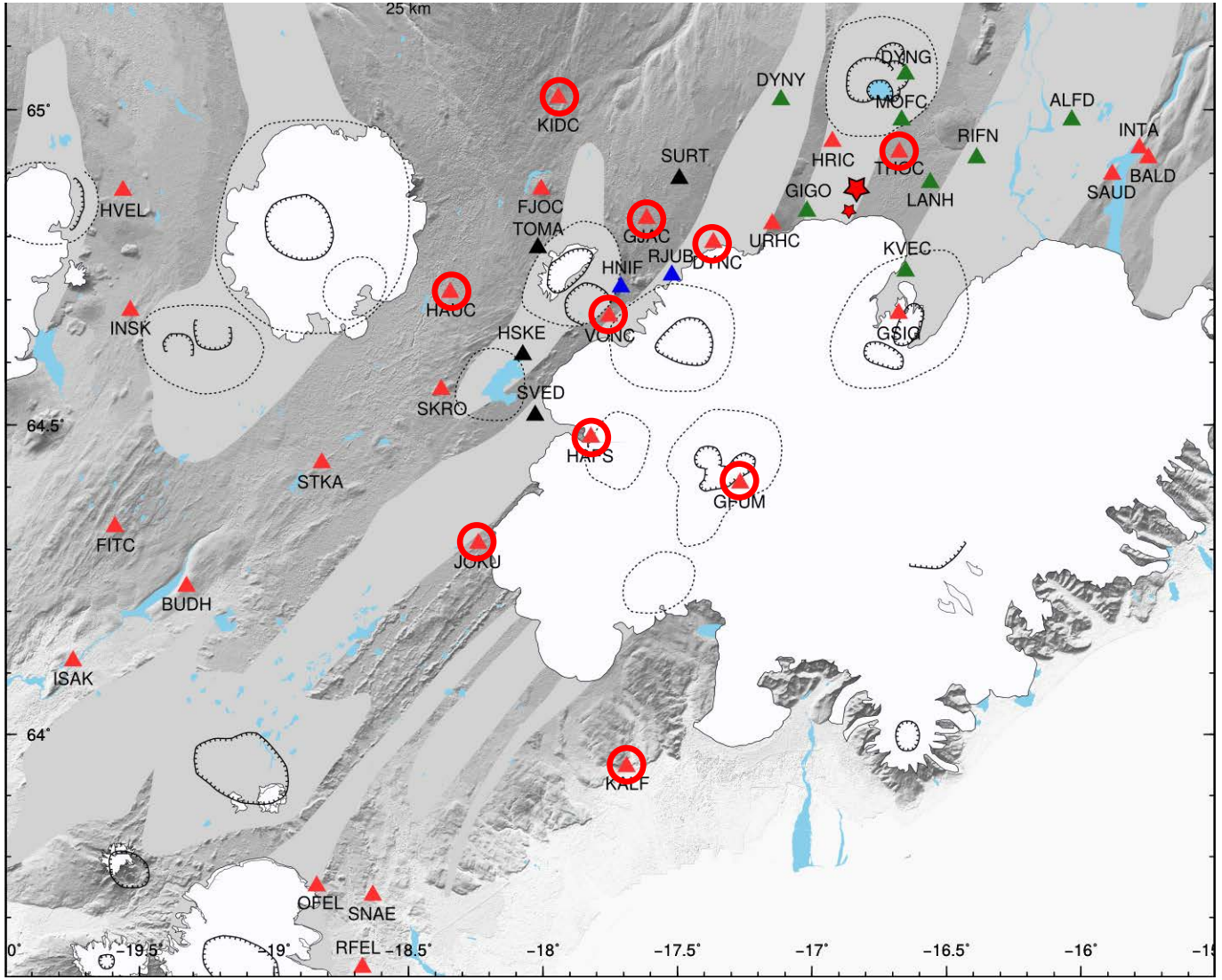
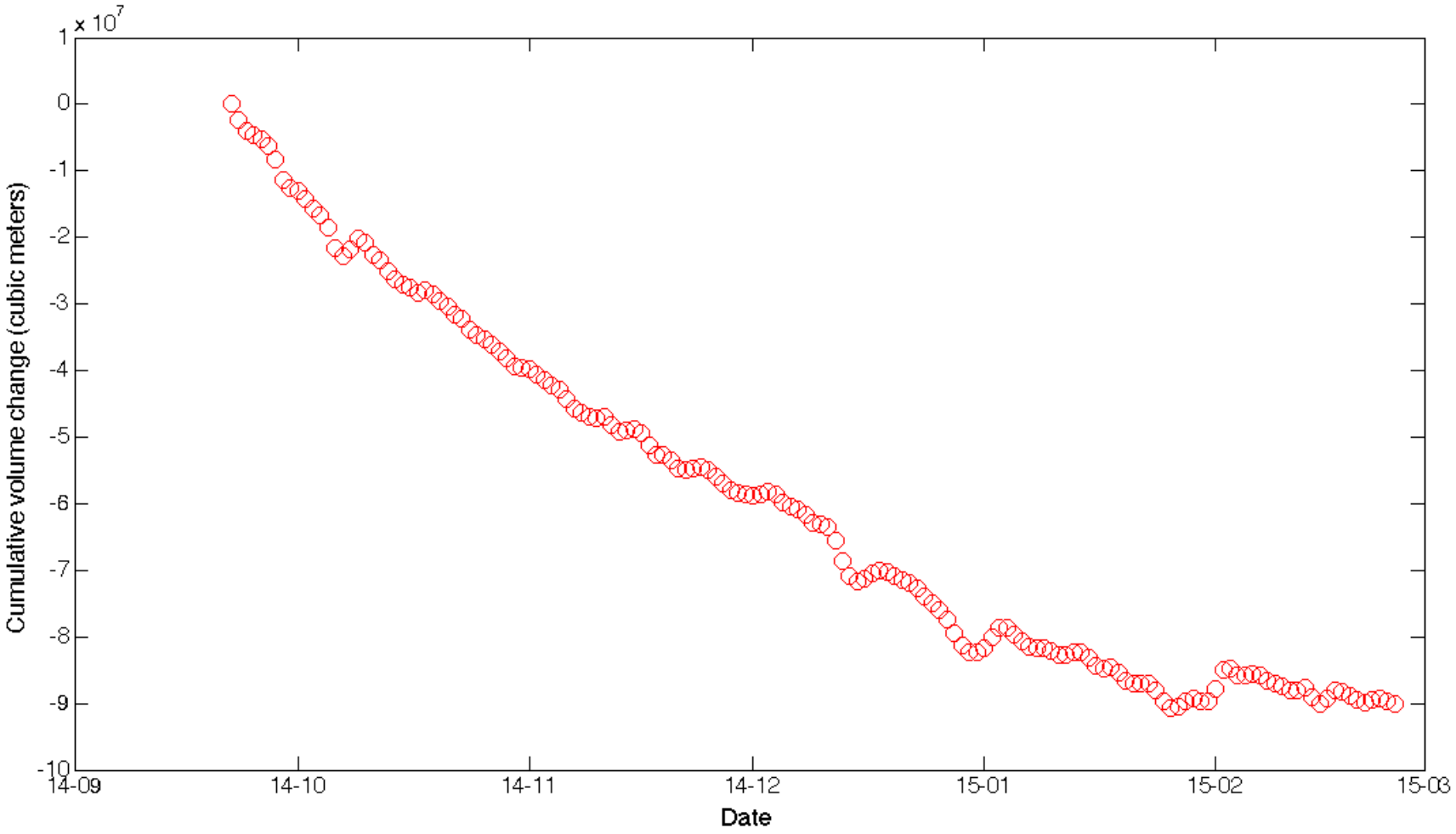
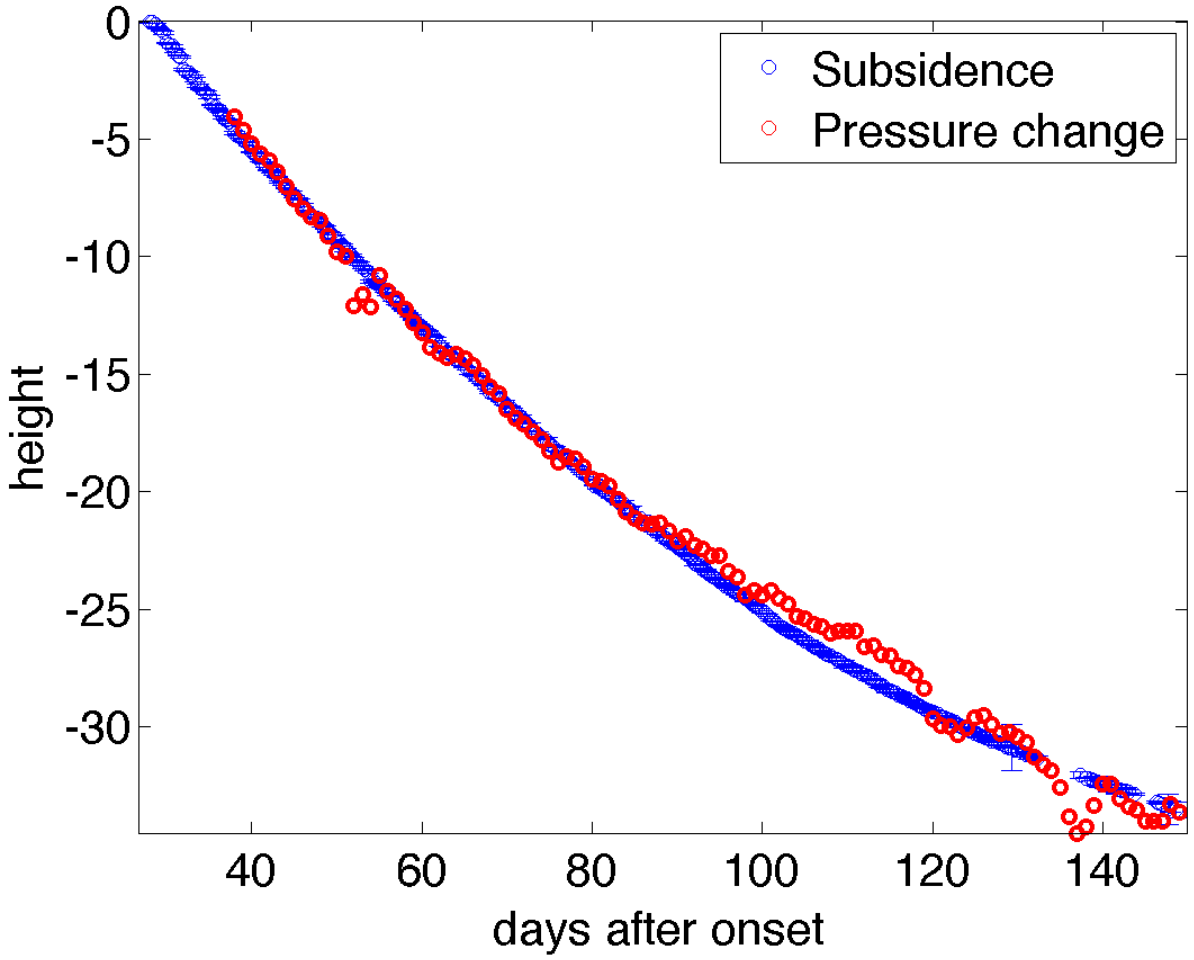
Modelling of farther GPS sites



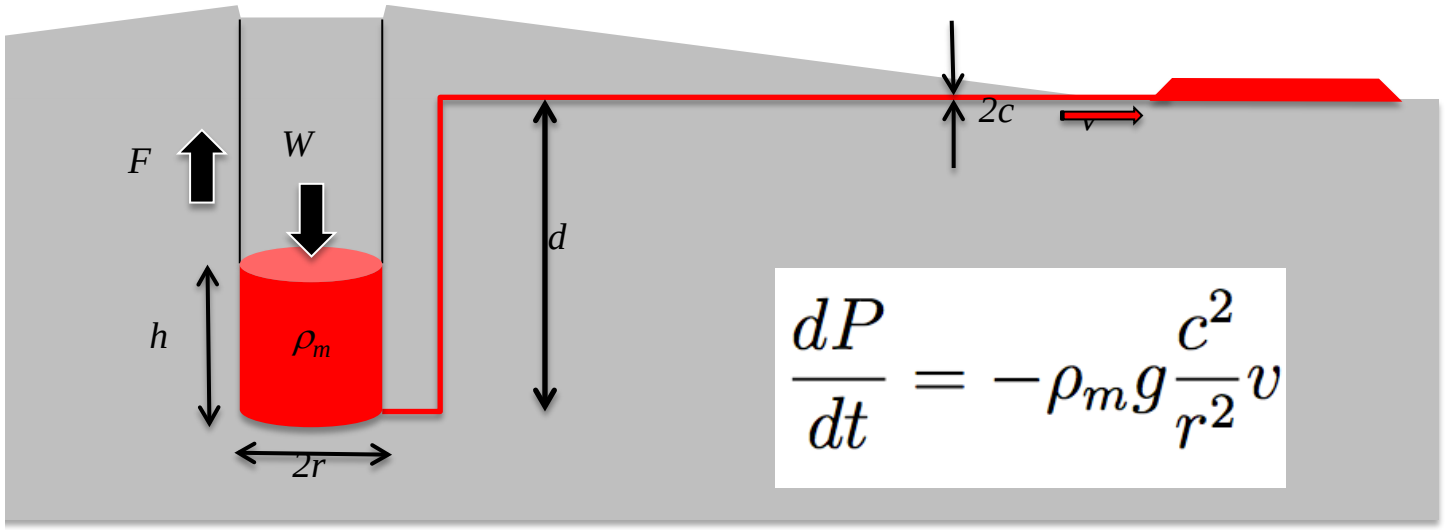
Inverted pressure change from GPS



Inverted volume change follows same curve

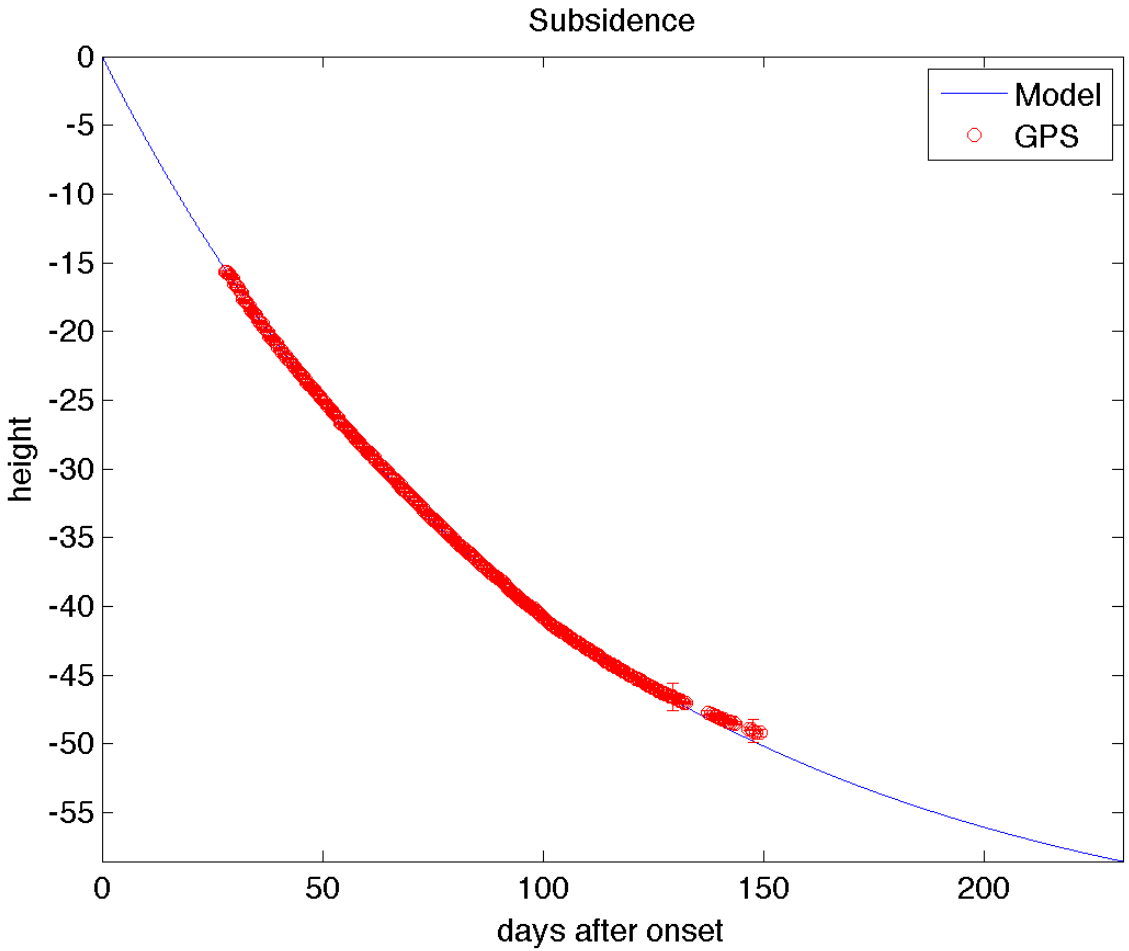


Coupled collapse and eruption model



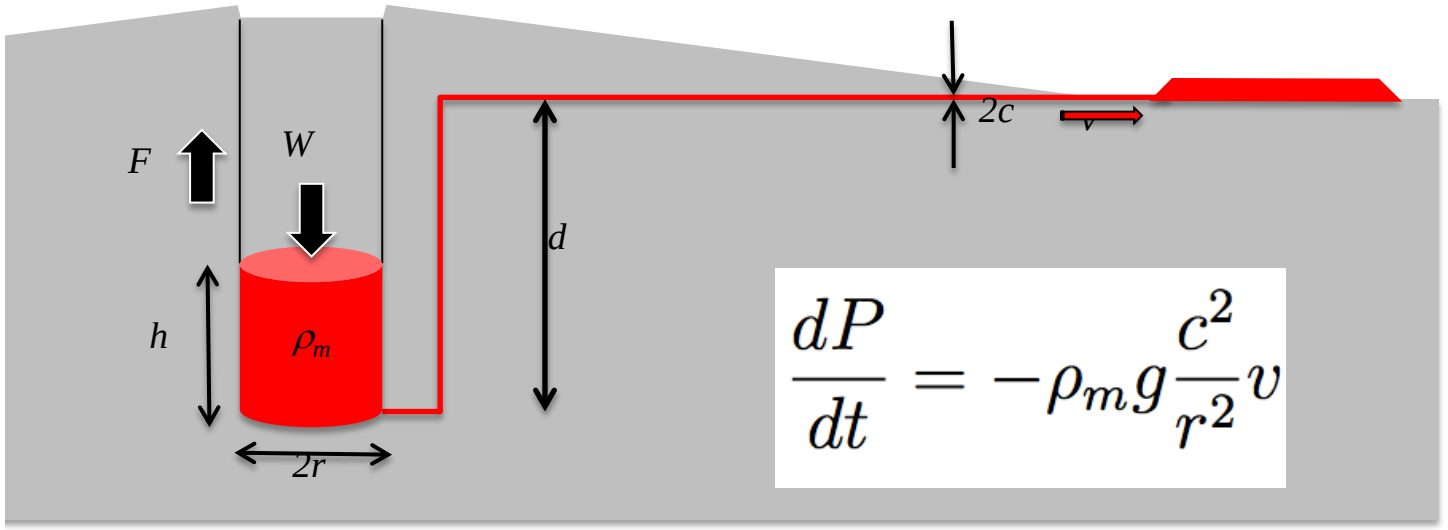
- Predicts exponential decay for subsidence if velocity proportional to pressure (laminar flow)

Laminar Flow (exponential)



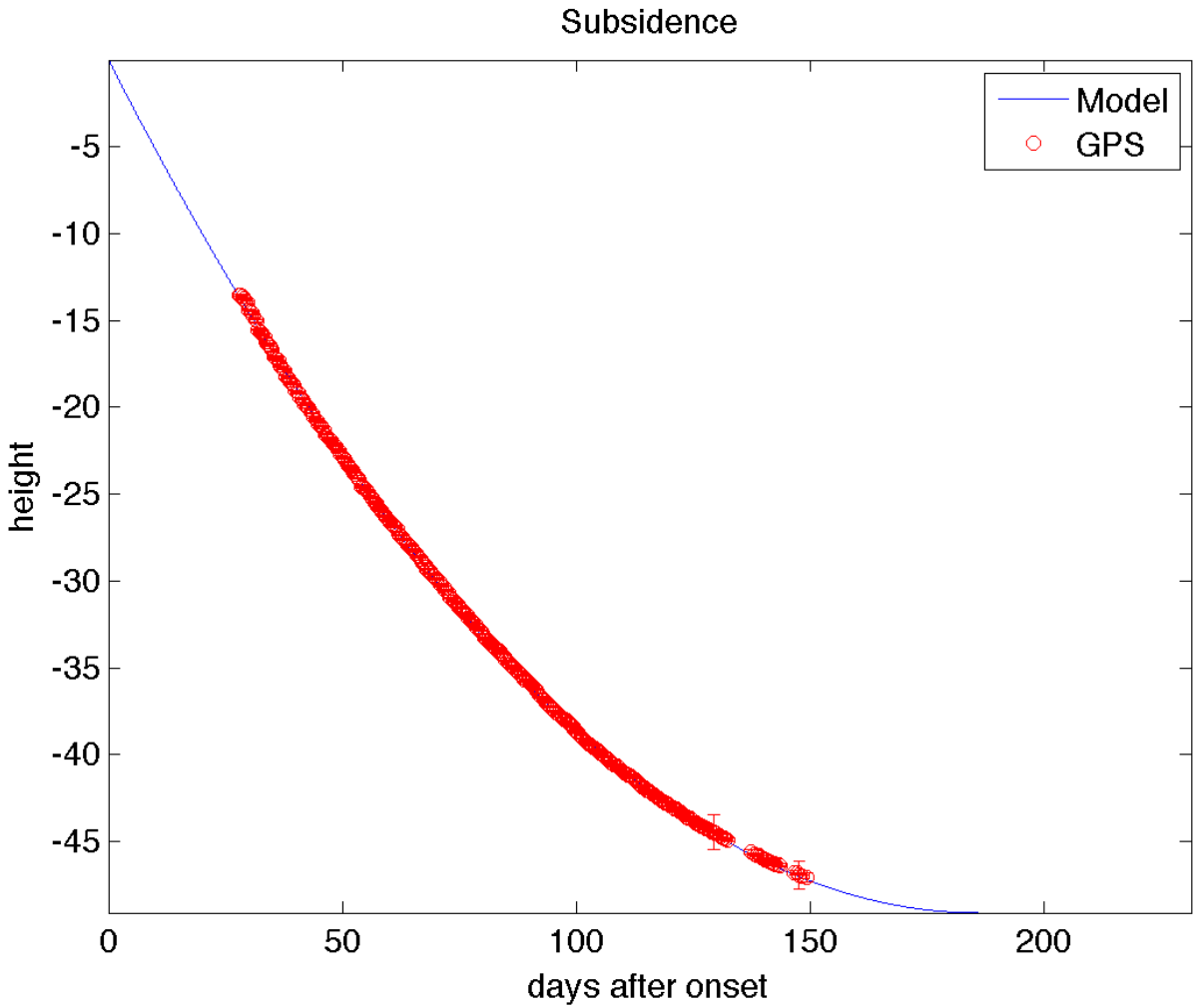
- Would continue for months

Coupled collapse and eruption model



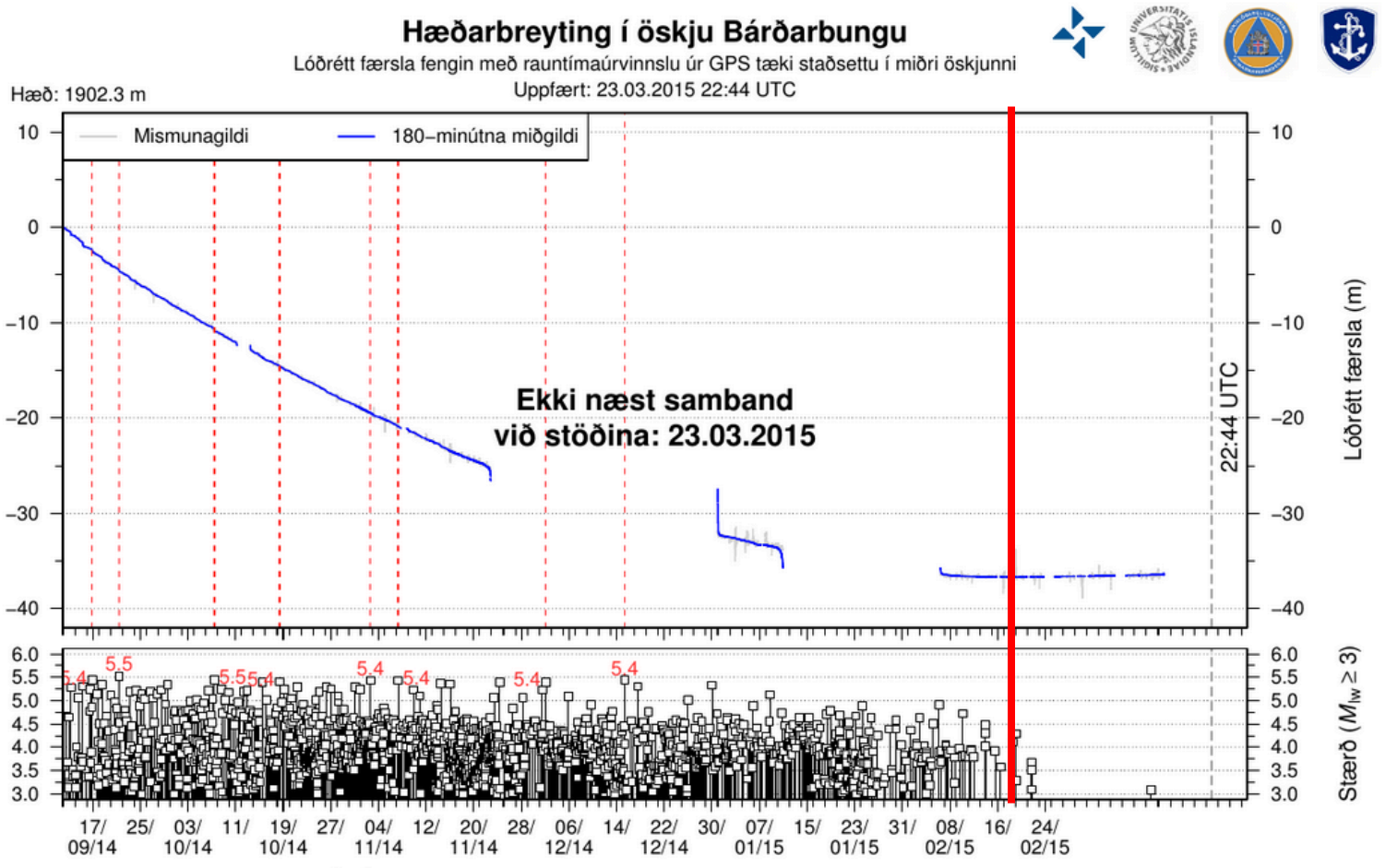
- Predicts quadratic decay for subsidence if velocity proportional to square root of pressure (e.g. turbulent flow)

Quadratic



- Predicts end-date of 17 Feb +/-2 days

How did it play out?



- Prediction not far off

End of the eruption – Feb 2015

- Lava drained from the main crater on the 26th/27th Feb 2015
- Field teams visited the area on the 1st March

Photo credit: Á Höskuldsson

Summary

- Dike propagation was complex but can be understood in terms of combination of strain energy and gravitational energy change

- Caldera subsidence dominated by same mechanism throughout – a simple model can explain the evolution

- Shows great promise for eruption forecasting (both start and end)