# Using microearthquakes to track repeated magma intrusions beneath the Eyjafjallajökull volcano, Iceland


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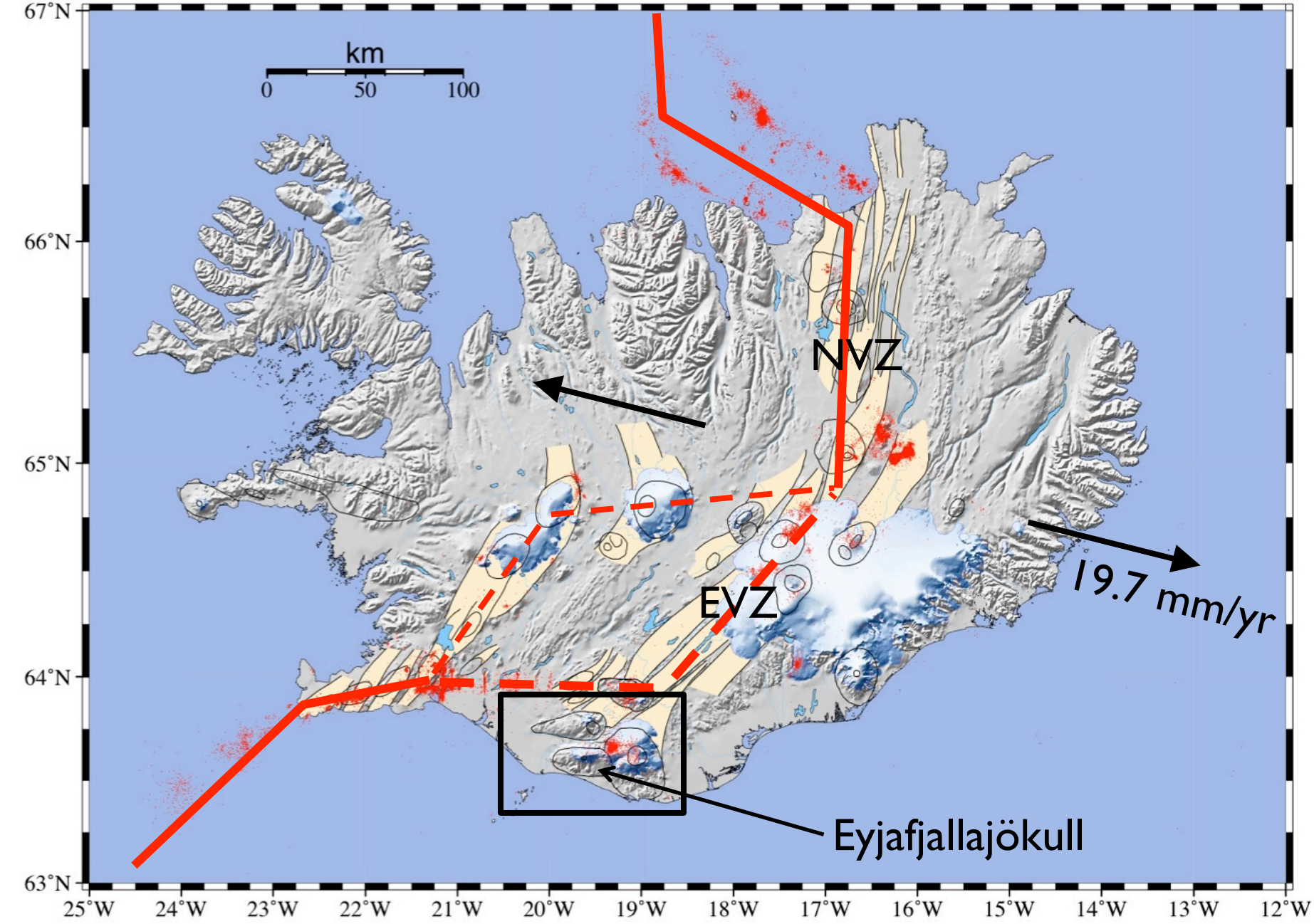
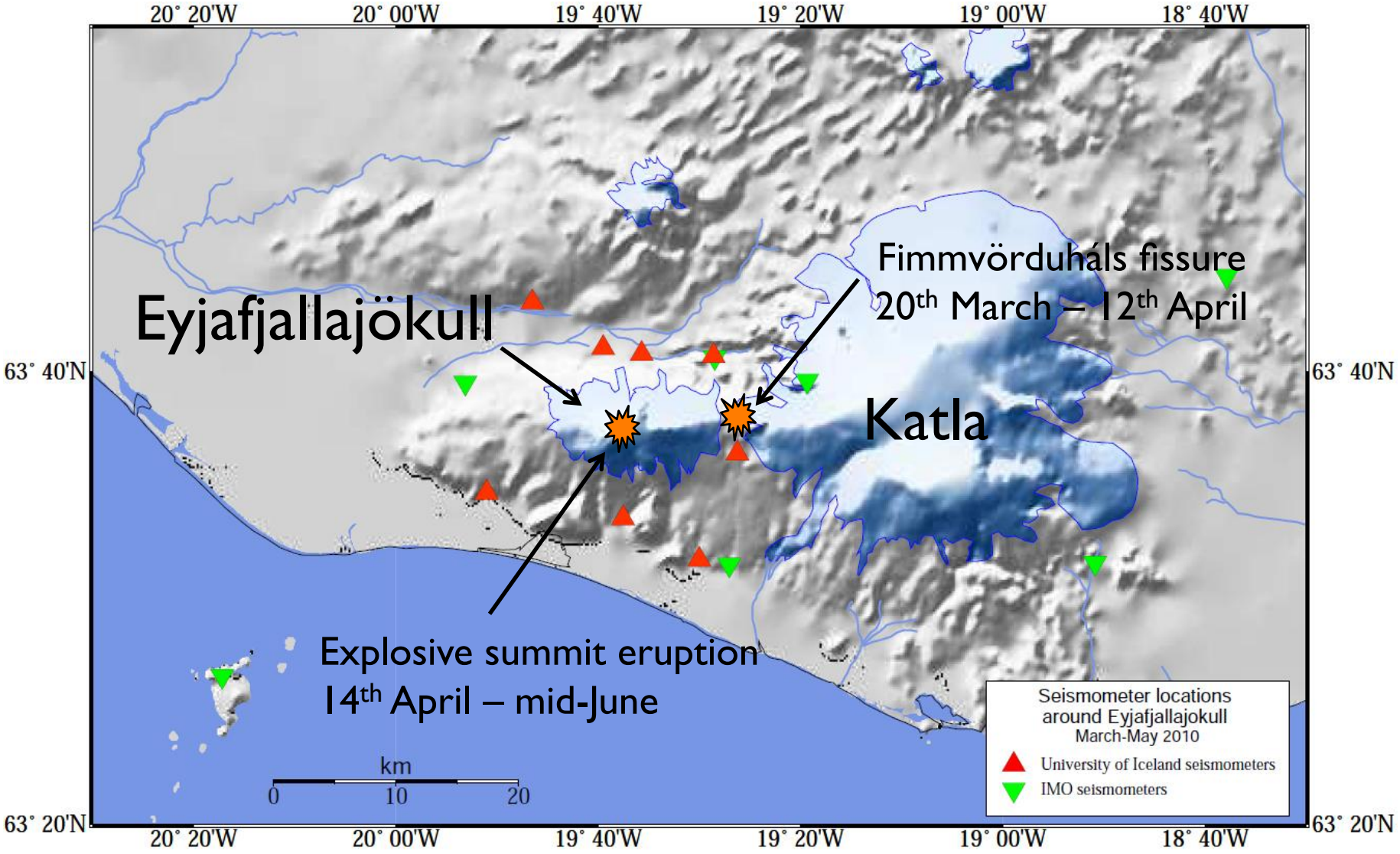
Tarasewicz *et al.* (2012), *Using microearthquakes to track repeated magma intrusions beneath the Eyjafjallajökull stratovolcano, Iceland*. J. Geophys. Res. (in press).

Tarasewicz *et al.* (2011), *Location accuracy of earthquake hypocentres beneath Eyjafjallajökull, Iceland, prior to the 2010 eruptions*. Jökull, 61, 33–50.


km
0
50
100
NVZ
EVZ
19.7 mm/yr
Eyjafjallajökull
67°N
66°N
65°N
64°N
63°N
25°W
24°W
23°W
22°W
21°W
20°W
19°W
18°W
17°W
16°W
15°W
14°W
13°W
12°W

# Eyjafjallajökull 2010

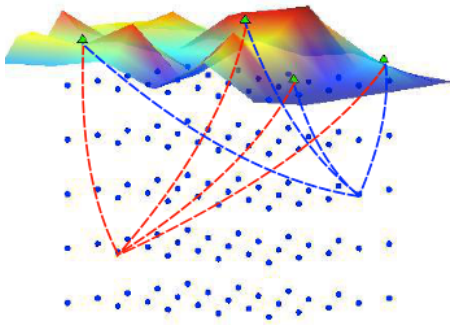


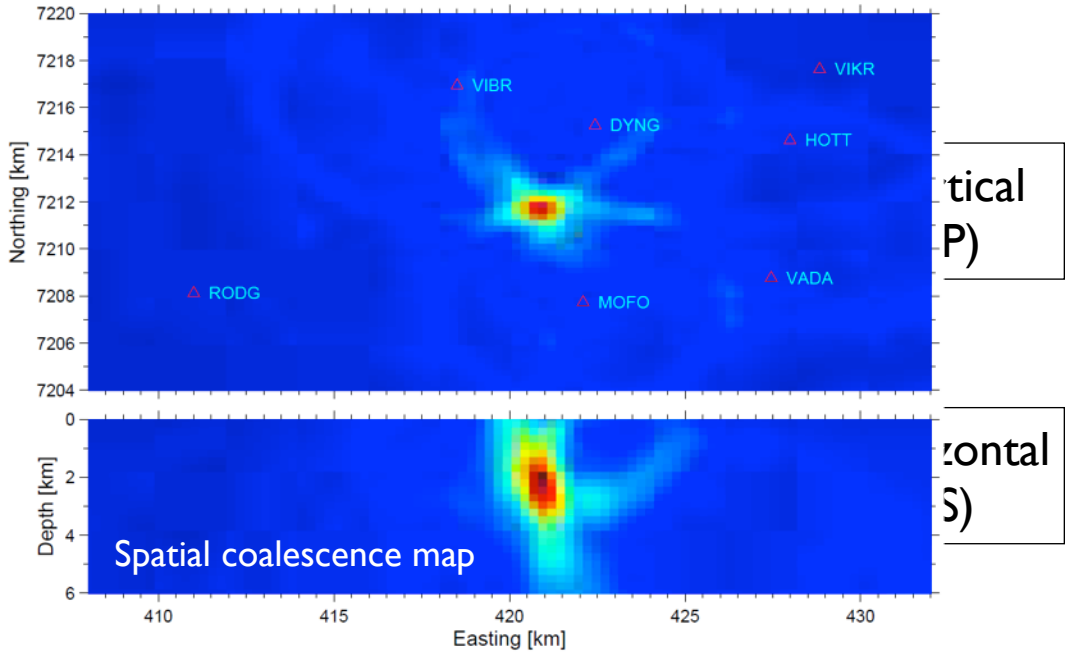
# Coalescence Microseismic Mapping (CMM)

## Automatic detection and location of earthquakes:

- Forward-model P- and S-wave travel times from each node to each seismometer
- STA/LTA of seismic waveform data continuously mapped as an 'onset' function at each station
- Onset function continuously migrated back from every station to find where the energy focuses in time & space

**→ Maxima in coalescence are most likely event origin times/ locations**

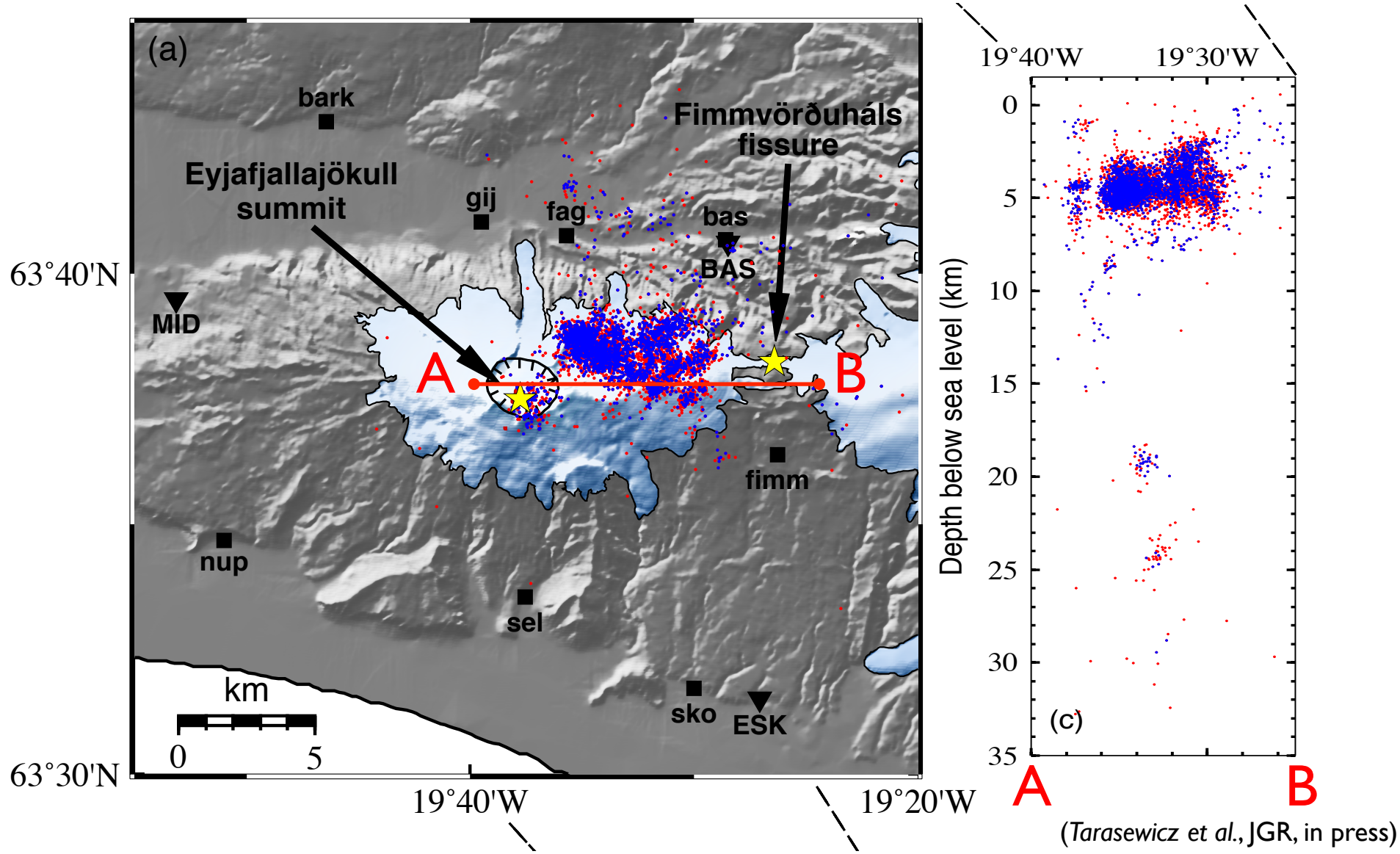





*After Drew, PhD thesis (2010)*

# Eyjafjallajökull seismicity 5th March – 31st May 2010

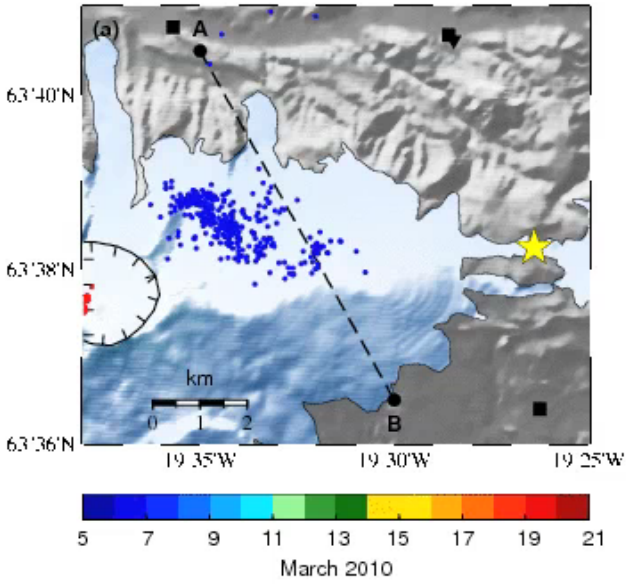
## (CMM locations)

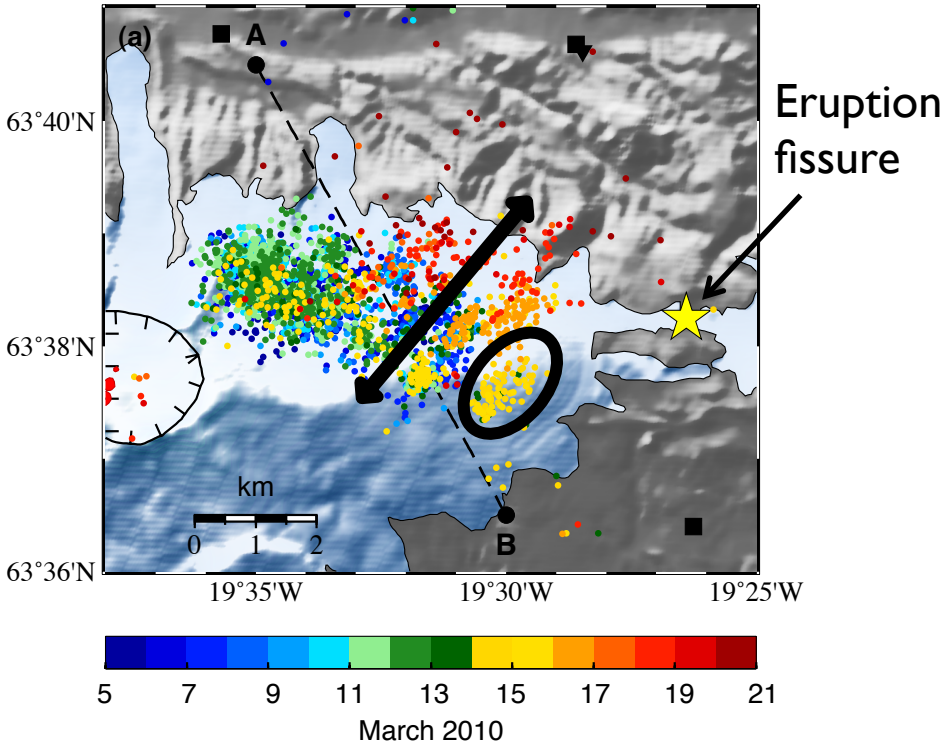


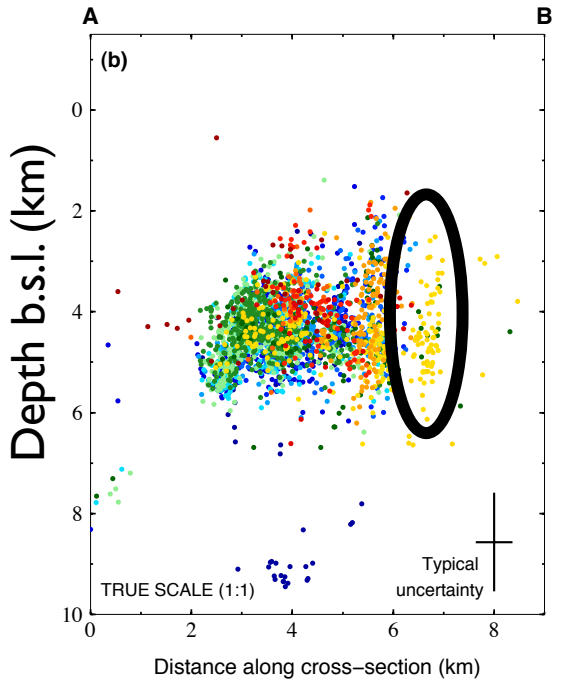

(*Tarasewicz et al.*, JGR, in press)

# Before the Fimmvörduháls fissure eruption

- Spatial & temporal clustering
- Complex intrusion/migration pattern
- NE-SW *en echelon* clusters (dykes?)

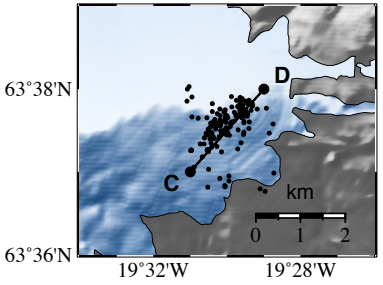


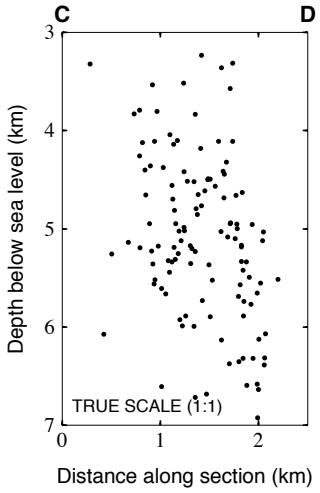




(*Tarasewicz et al.*, JGR, in press)

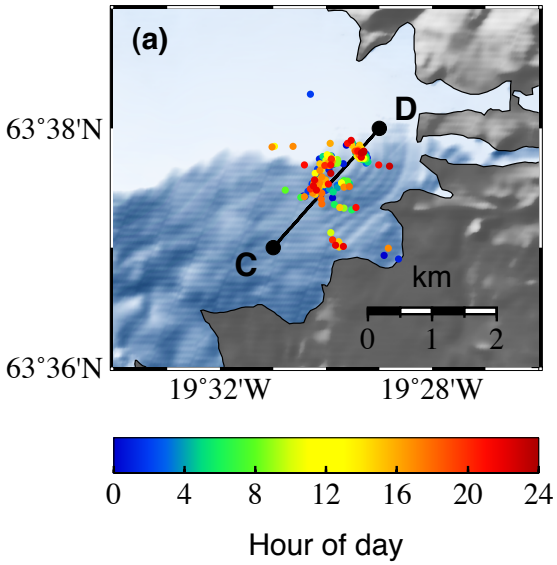
# Refining automatic earthquake locations by relative relocation

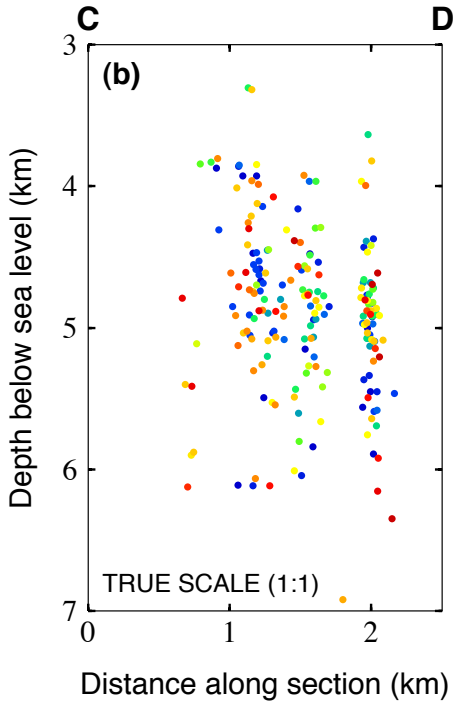



- 204 best events on a single day from CMM.
- P/S arrival picks refined manually.
- Earthquakes re-located using double-difference relative relocation algorithm (*Waldhauser & Ellsworth*, 2000).

March 14th 2010

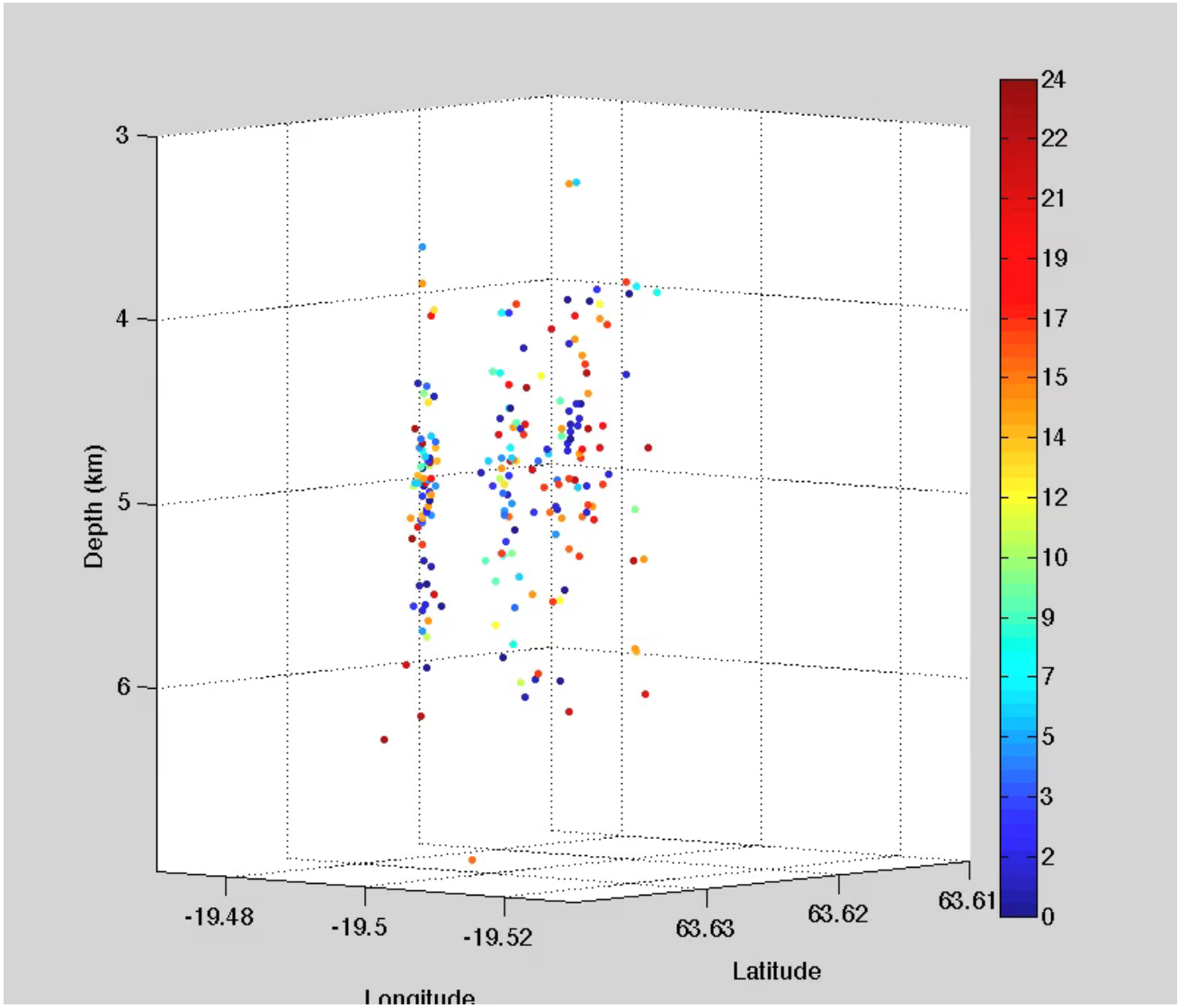



(*Tarasewicz et al.*, JGR, in press)

# Before the Fimmvörduháls eruption (14th March)

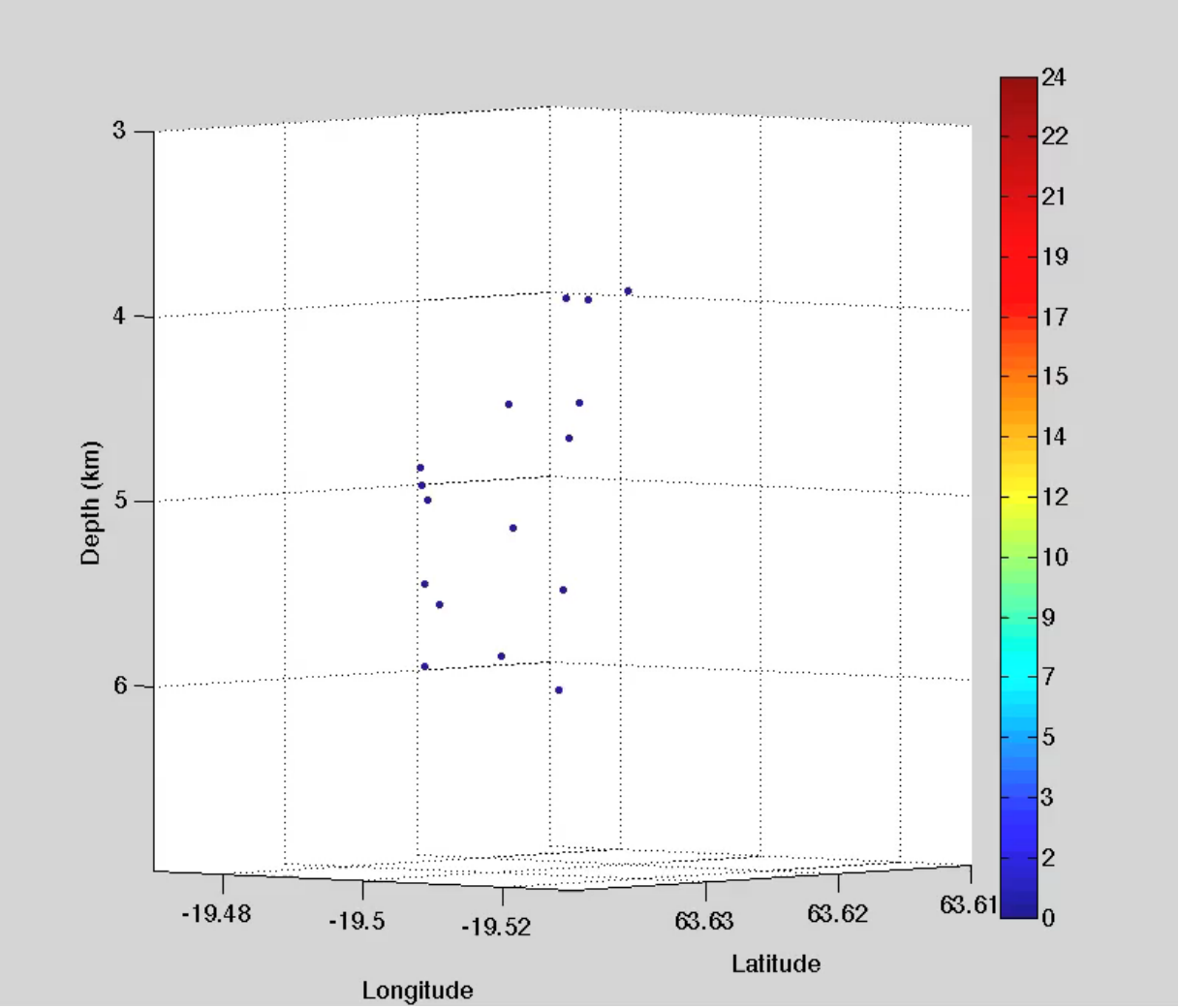
2 km



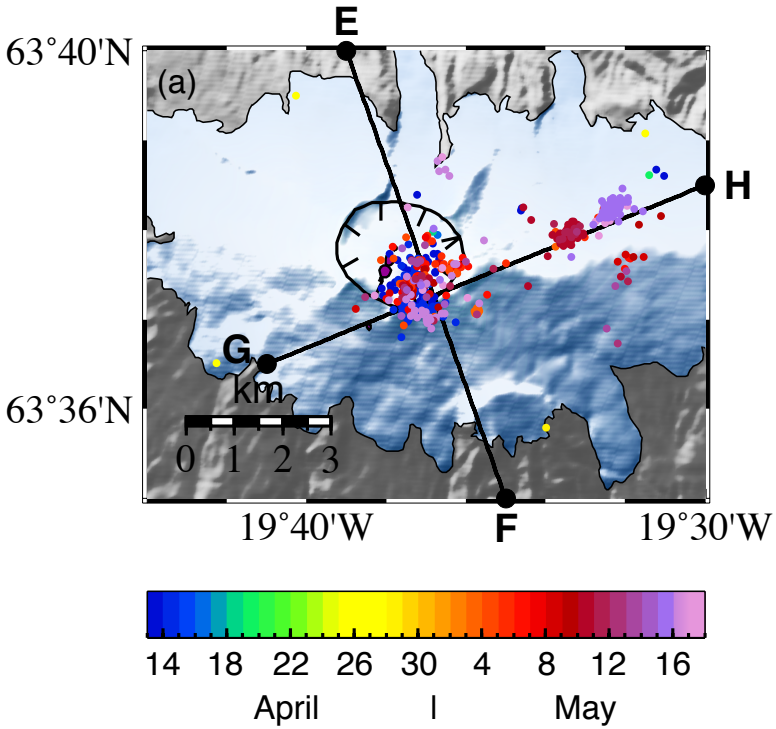

Colour-coding: hour of the day, 14th March

# Before the Fimmvörduháls eruption

Mar 14, 1 frame/hr

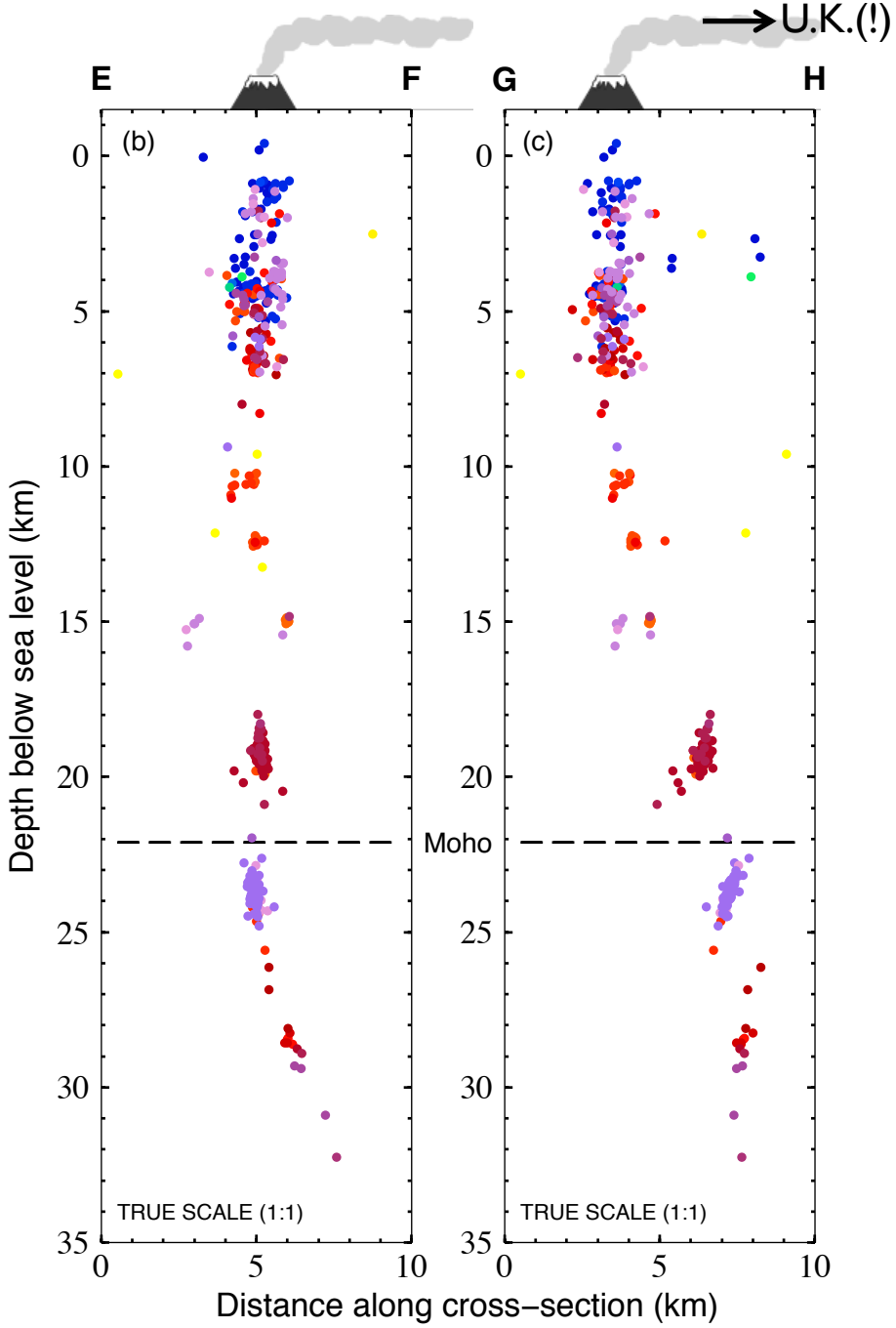



Colour-coding: hour of the day, 14th March




# During Eyjafjallajökull summit eruption

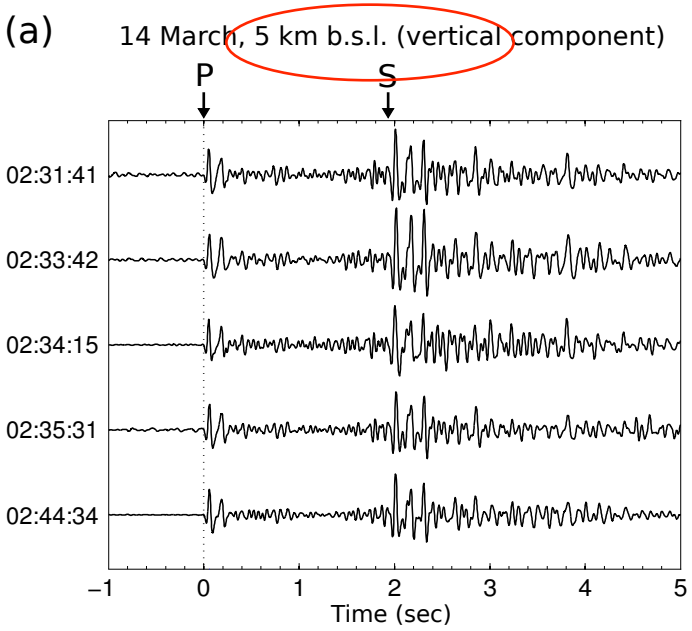
- Initial shallow seismicity (blue dots)
- 2-3 week quiet period
- Later, deep injections (30+ km, red/ purple dots)

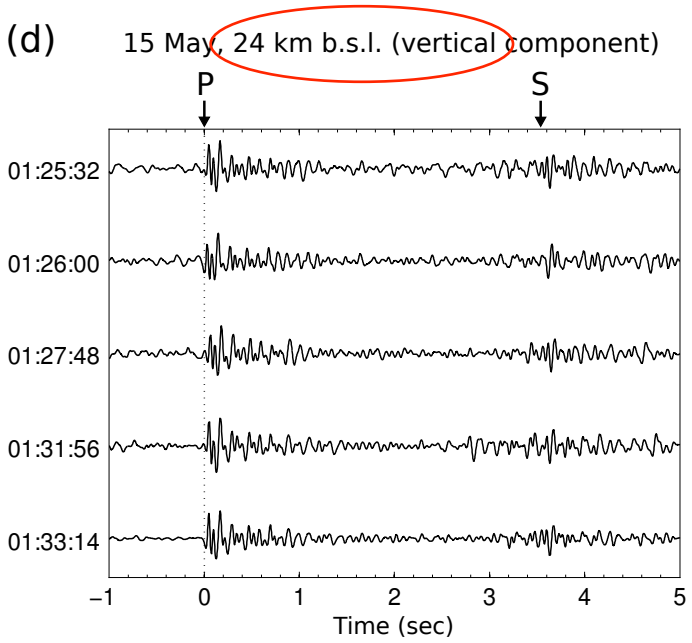


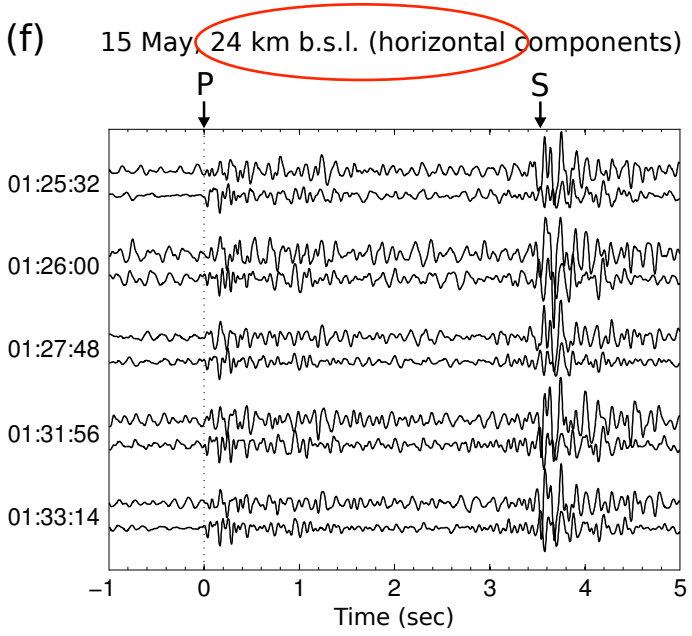

(*Tarasewicz et al.*, JGR, in press)

# Waveforms

- Clear P- & S-wave arrivals indicate brittle failure even for deep events
- Closely similar waveforms within sub-clusters require repeatable, co-located mechanisms with similar orientation



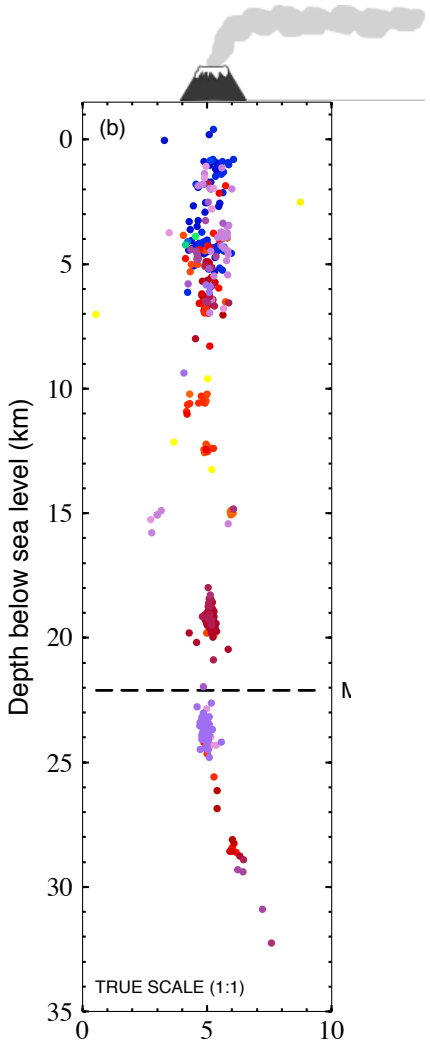



# What processes are generating the seismicity?

- Brittle events in ductile regime:
  → Magma movement causing locally high strain rate.

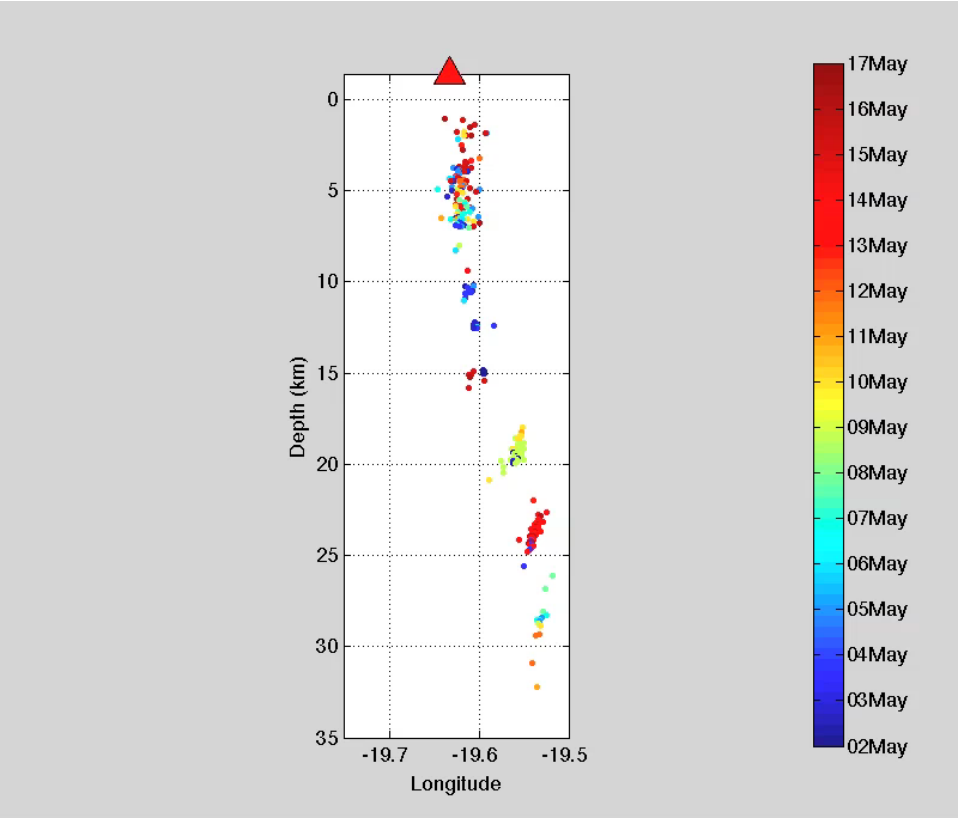
- Spatial clusters with aseismic gaps in between & repeated similar waveforms within clusters:
  → bottlenecks in the conduit acting as valves (above melt pockets)? Shunting plugs of solidified magma?

- Contemporaneous seismicity across depth ranges:
  → NOT dyke tip propagation. Re-fracturing of conduit walls?



# Summary

- At Eyjafjallajökull most of the seismicity preceded both eruptions in a complex with vertical dykes/pipes under the NE flank.
- Seismicity during the summit eruption illuminates a magma pathway all the way from c. 30km depth up to the eruption site.
- Fracturing mechanisms remain uncertain, but are more complex than solely propagating dyke tips.




REFERENCES:
Tarasewicz, J., B. Brandsdóttir, R. S. White, M. Hensch and B. Thorbjarnardóttir (2012), *Using microearthquakes to track repeated magma intrusions beneath the Eyjafjallajökull stratovolcano, Iceland*. J. Geophys. Res. (in press).
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