Karlsruhe Institute of Technology

Migration-based Detection and Location of the Seismicity Induced at Rittershoffen Geothermal Field (Alsace, France)

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AGIS Workshop on Induced Seismicity

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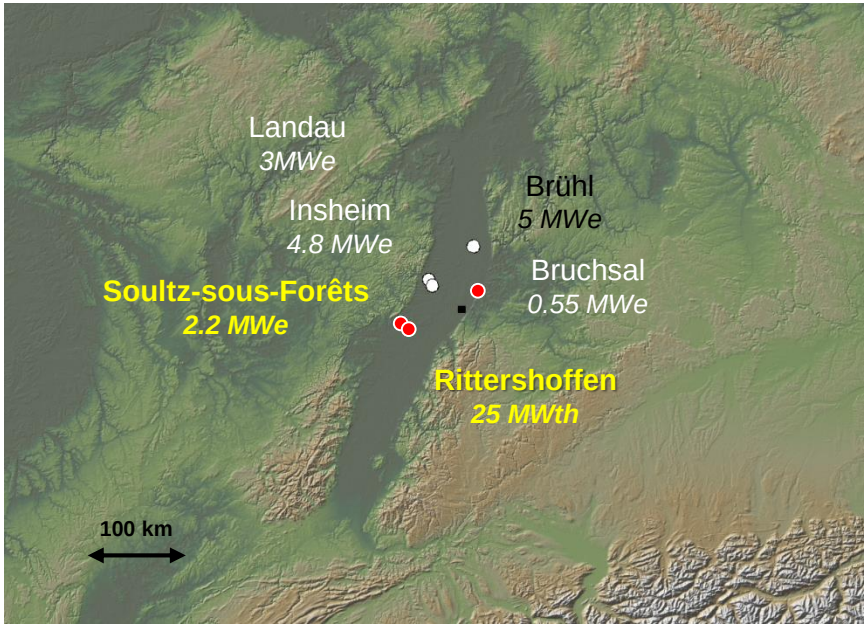
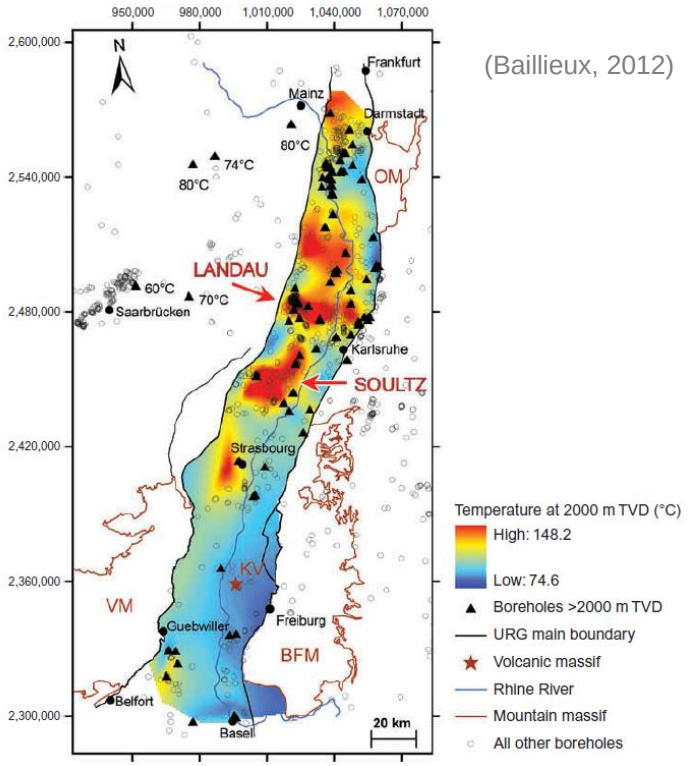
Davos Schatzalp, Switzerland

Rittershoffen geothermal field

- Upper Rhine Graben
- EGS field for process heat 24 MWth
- Doublet @ ~2.5 km depth
  - Triassic sandstone
  - Paleozoic granite
- 70 L/s / 160°C





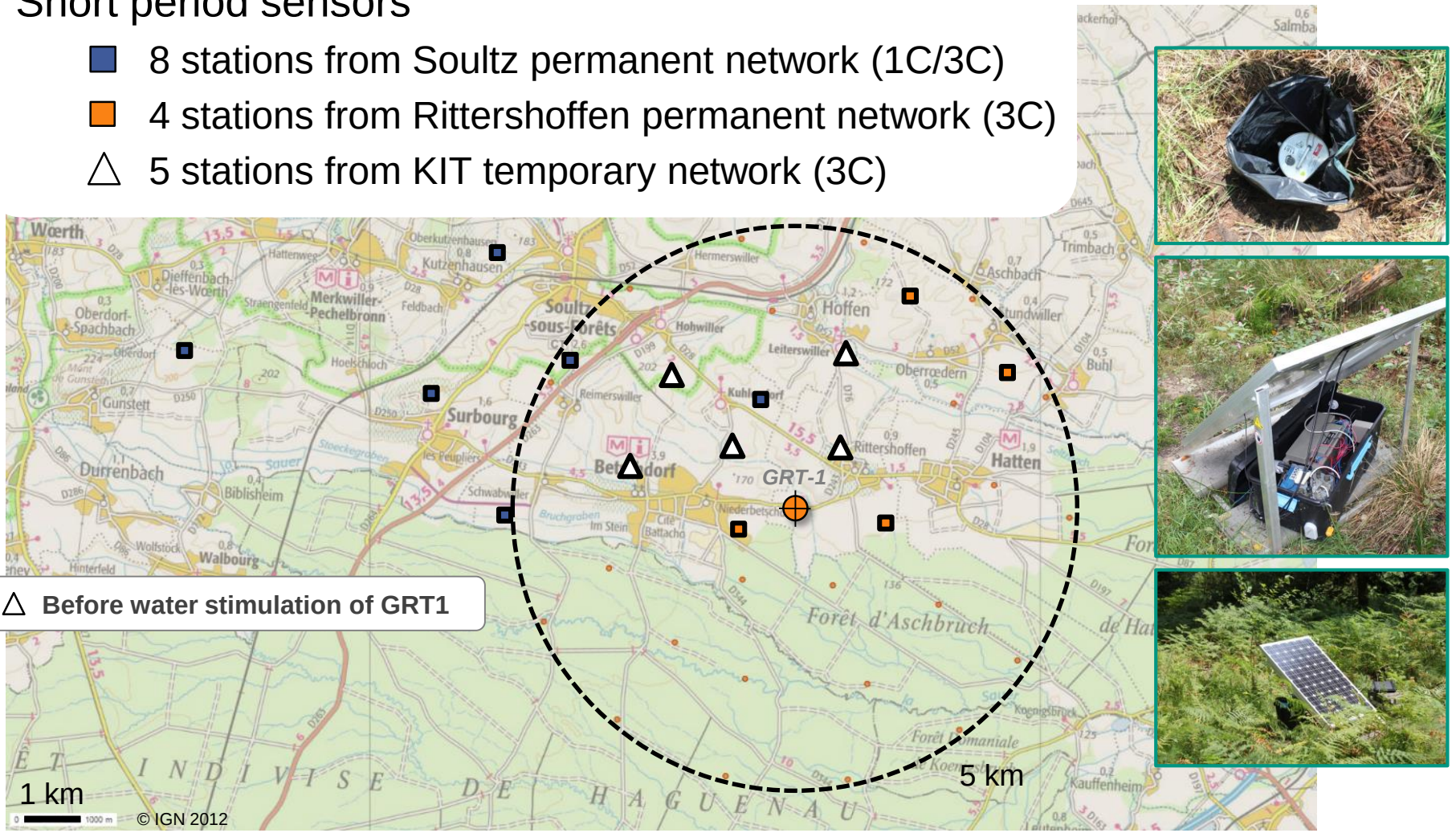
(Baillieux, 2012)

- Dec. 12: GRT1 drilled
- Jun. 13: GRT1 stimulation
- *Jul. 14: GRT2 drilled (no stimul.)*

Seismic network during GRT1 stimulation

Short period sensors

- 8 stations from Soultz permanent network (1C/3C)
- 4 stations from Rittershoffen permanent network (3C)
- △ 5 stations from KIT temporary network (3C)



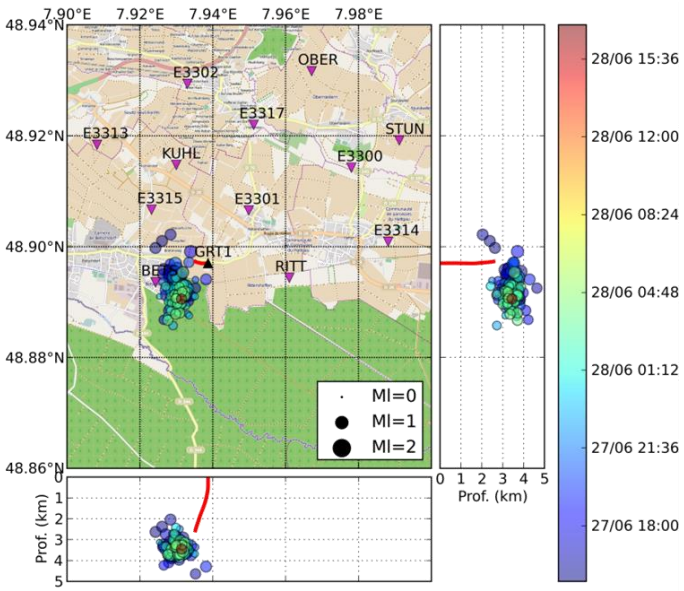
△ Before water stimulation of GRT1

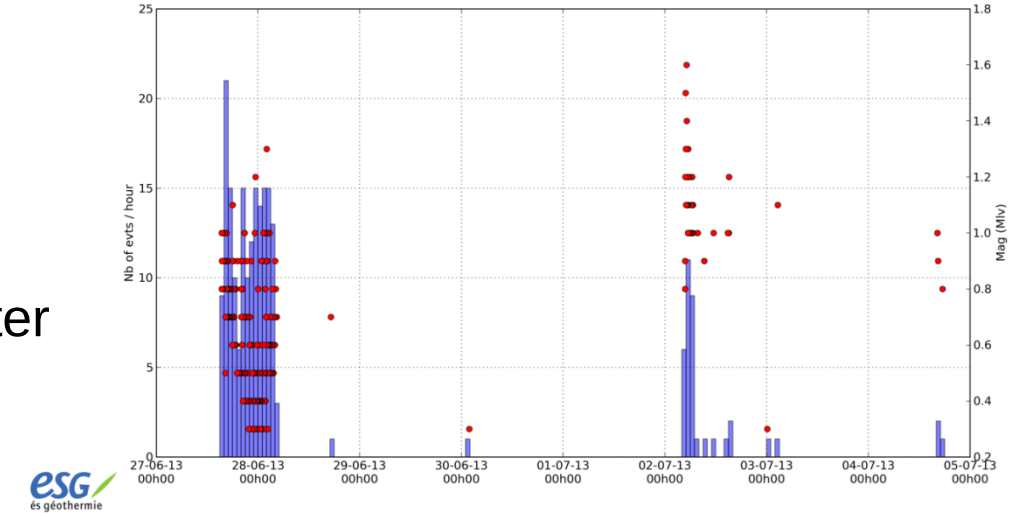
GRT1 stimulation induced seismicity

Preliminary (semi-)automatic results

(Obtained using SeisComp3)

- 174 events during stimulation
- 37 events 4 days later
- Max. M_{LV} = 1.3 during / 1.6 after

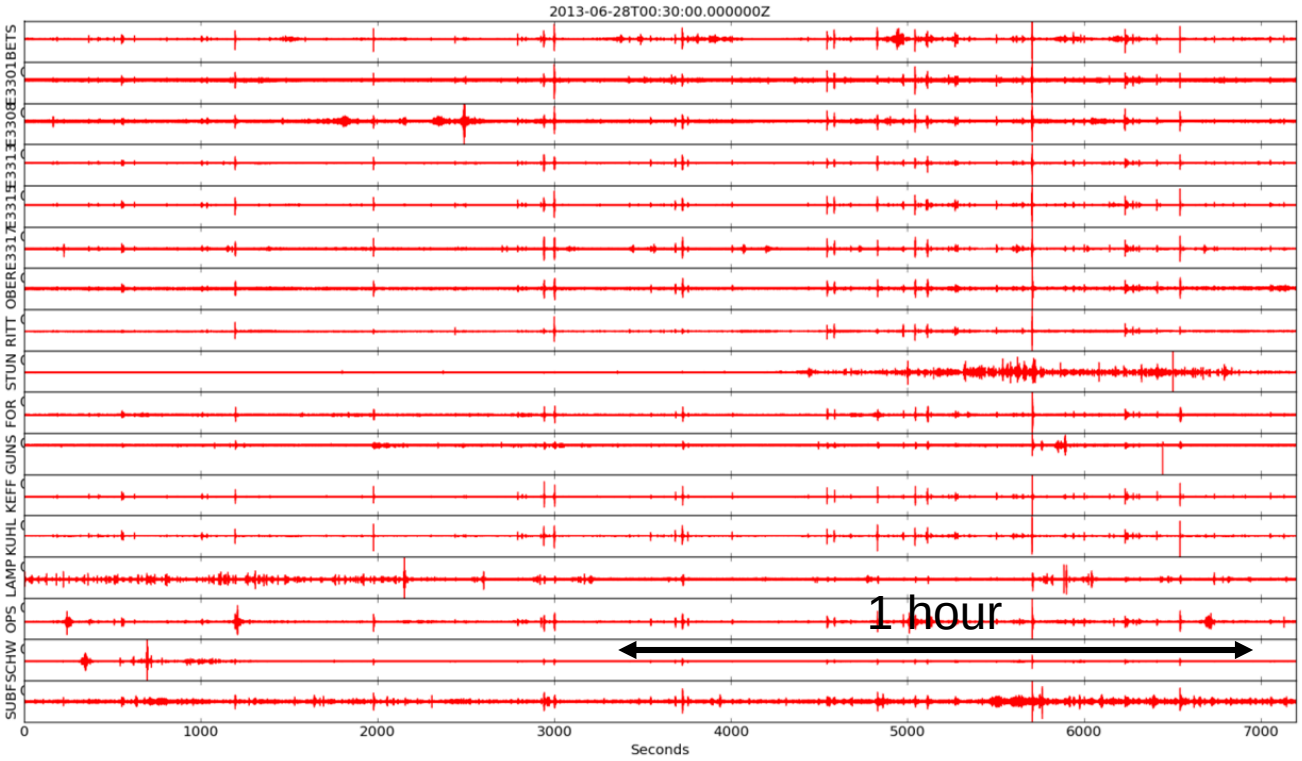




- Cloud close to BoH
- Centre deeper than BoH
- ~ 1 km EW x 2 km NS x 2 km Z

Motivation

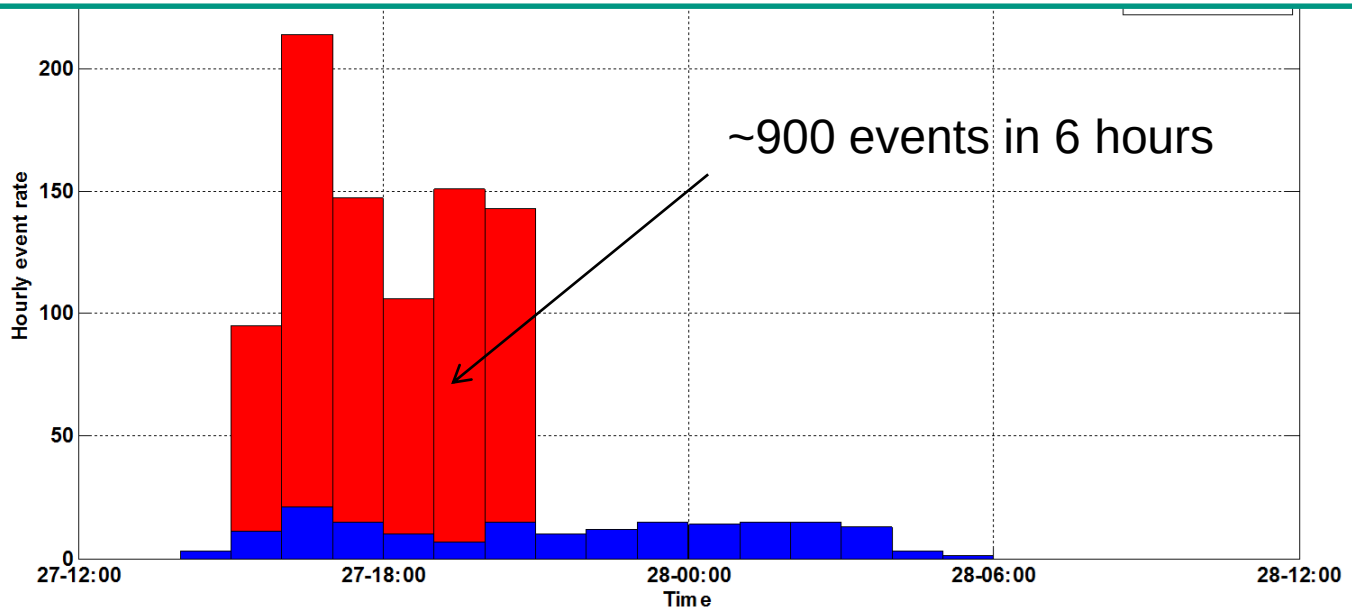
- > 100 event/hr
- Saturation of real-time manual processing



Motivation

- > 100 event/hr
- Saturation of real-time manual processing

⇒ Test a network-based automatic detection and location technique
⇒ Calibrate it / Compare it with exhaustive manual (post-)processing



Waveloc description

- Applied to the Piton de la Fournaise Volcano (Langet et al., BSSA, 2014)
- Automatic kurtosis-based migration detection and location technique

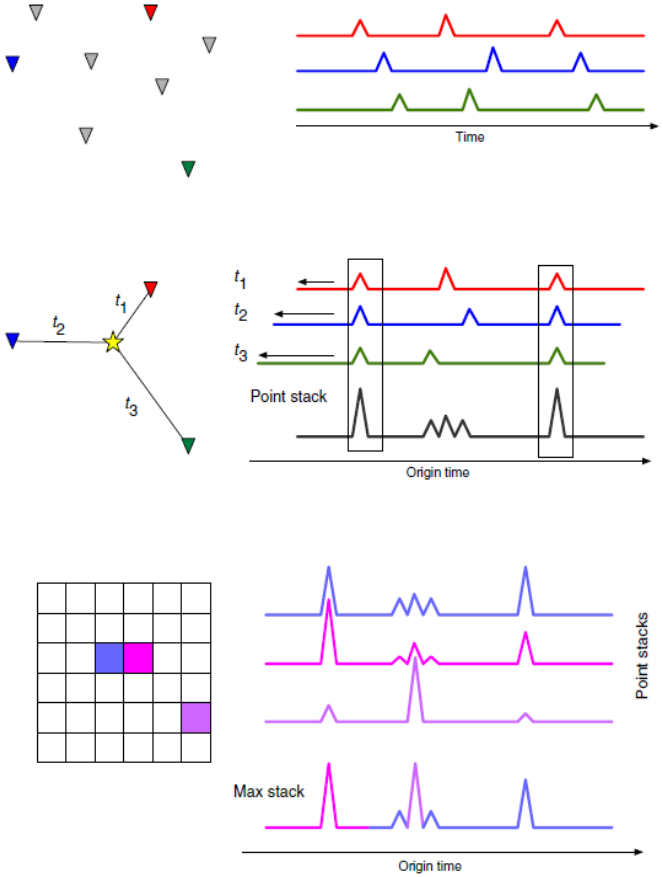
1. Pre-processing

- Raw channel filtering
- Detection function computation: Kurtosis

2. Migration

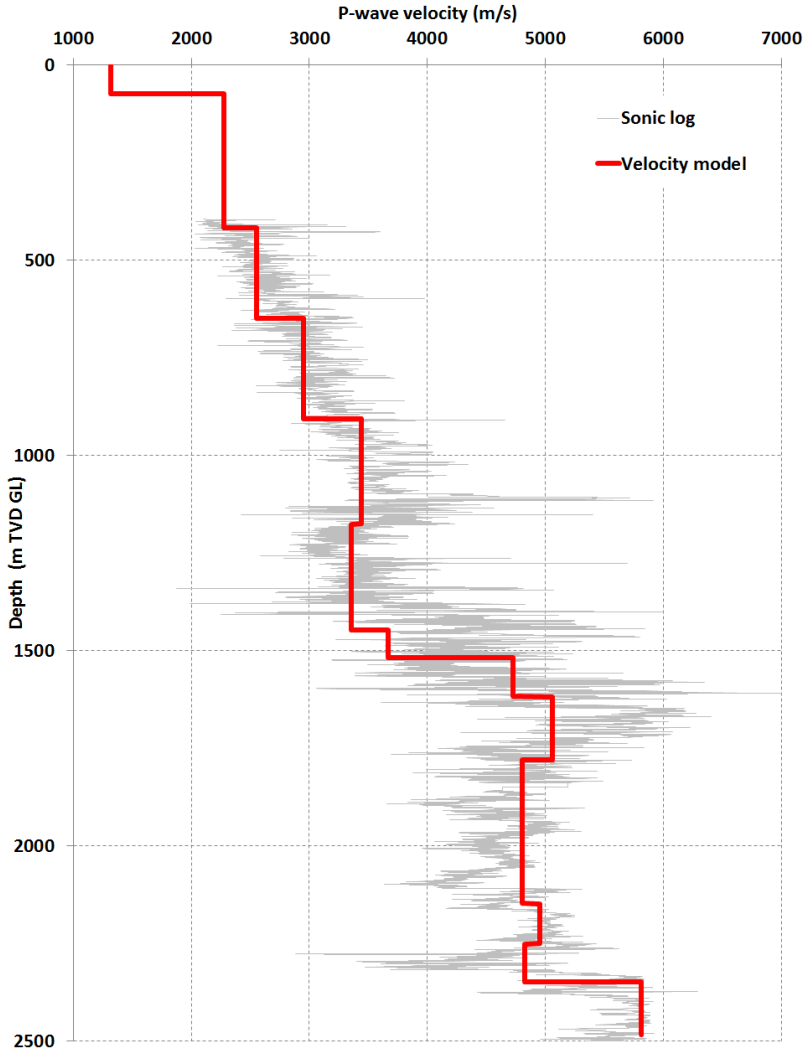
- Move-out correction
- Stack
- Store $max_{XYZ}(t_i)$

3. Detection Location



Present application of Waveloc

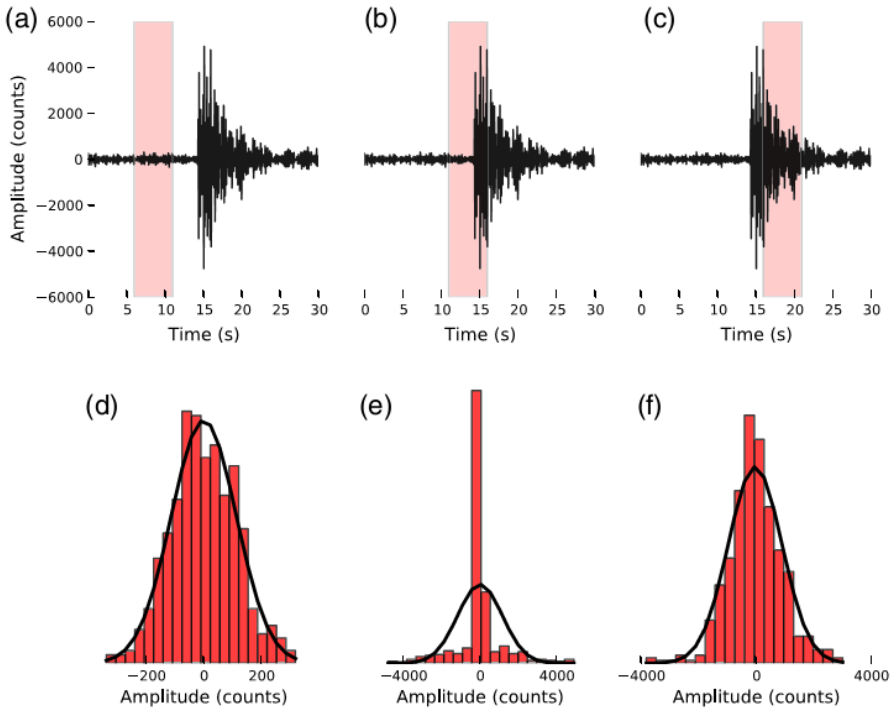
- P-wave only
- Velocity model
  - 1D layered
  - Obtained from 0VSP
- Database
  - 15 Z-components
  - 27 Jun 14:30 – 20:30
    - Exhaustive manual processing (857)

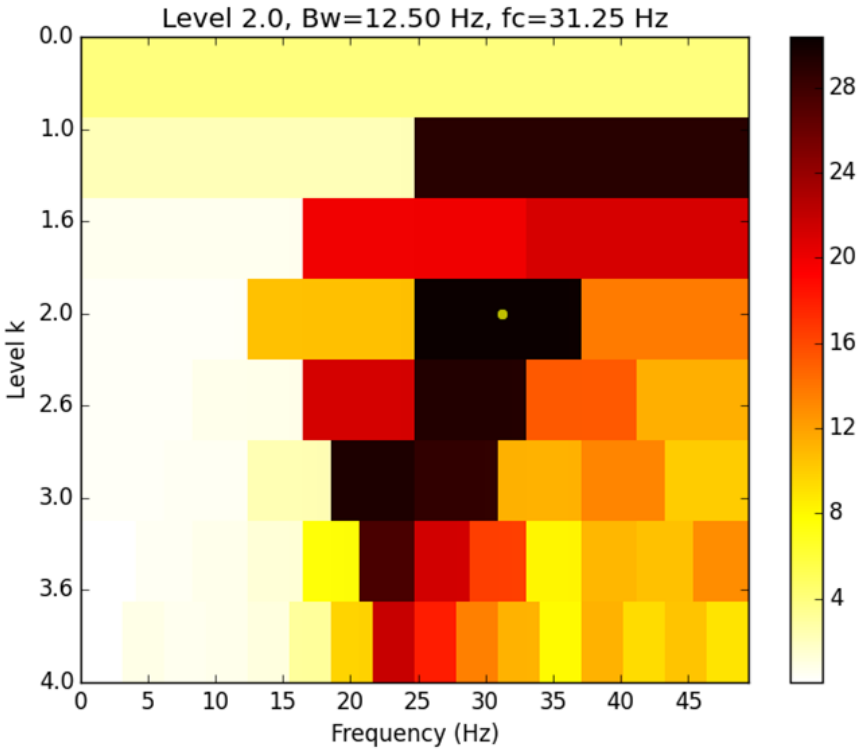


Data pre-processing

- Objective:
  - To enhance P-wave arrivals on each channel
  - To tune the kurtosis calculation

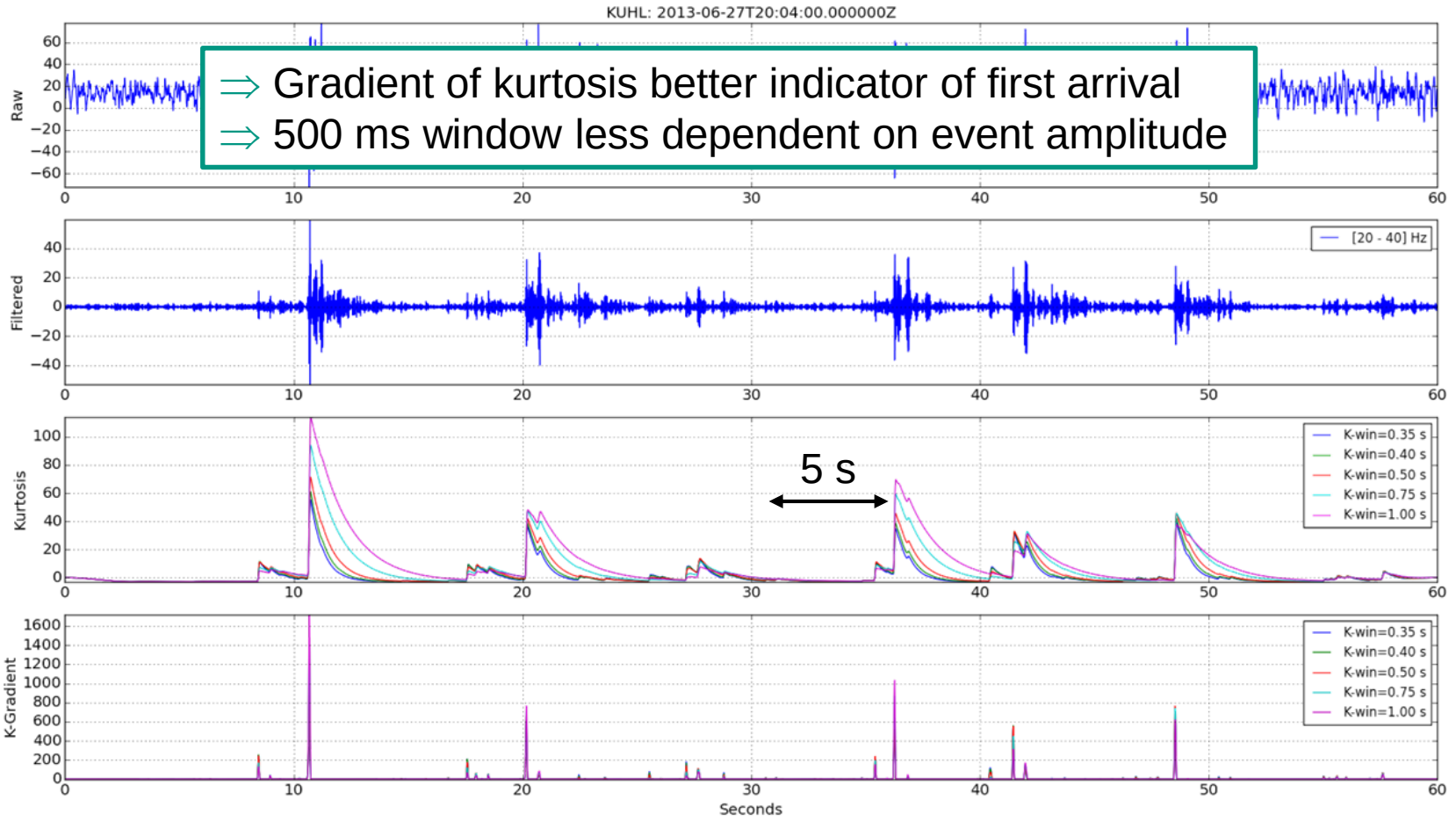
KUHL





Data pre-processing

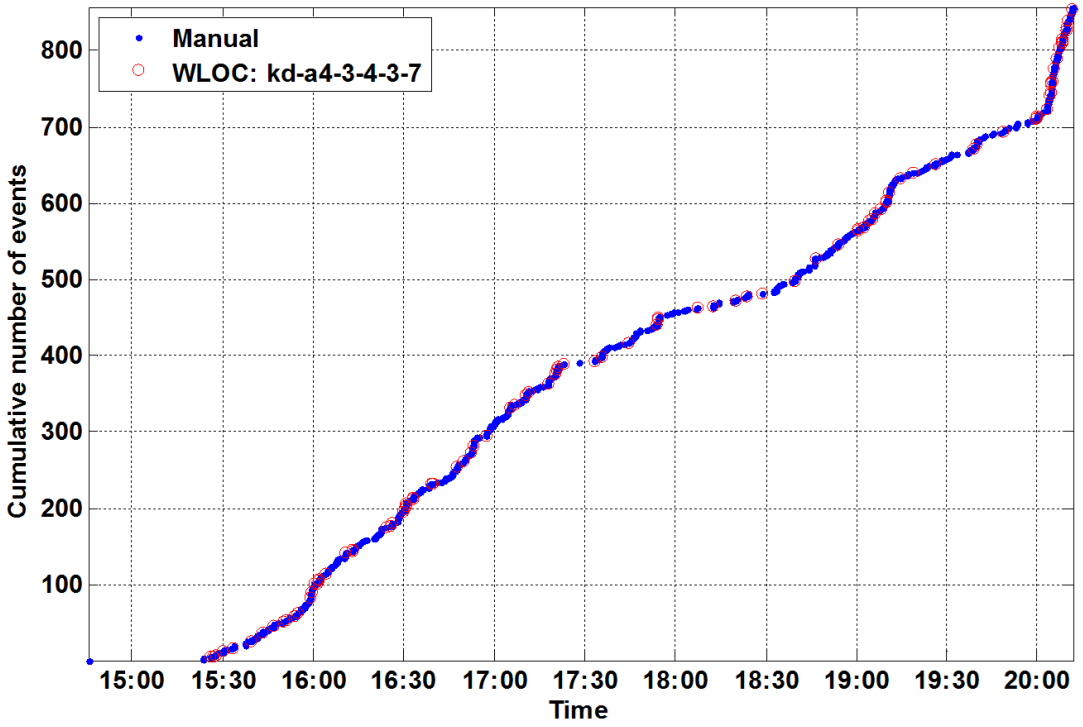
- Raw – Filtered – Kurtosis – Gradient of kurtosis



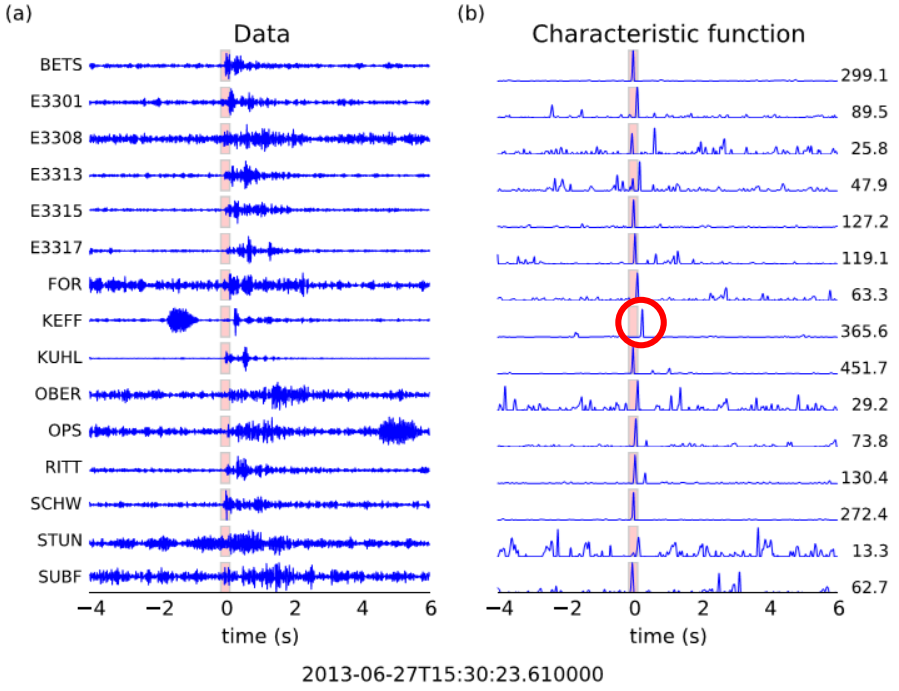
Event detection

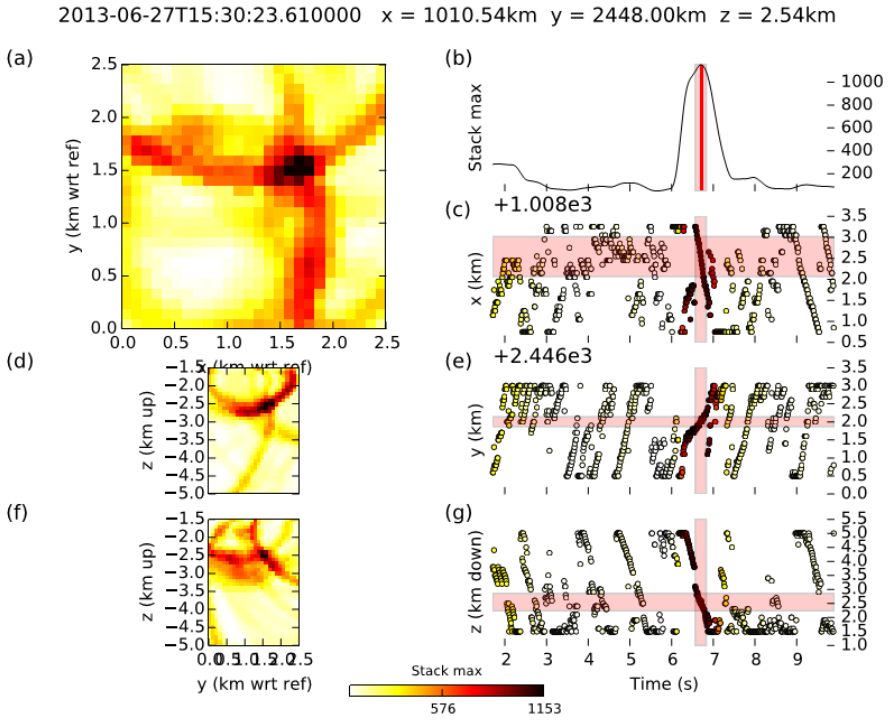
- Criteria
  1. Threshold on migrated trace for a given number of stations (7)
  2. SNR on filtered trace (3)
  3. SNR on kurtosis trace (4)

- Comparison with manual
  - Dt < 0.3 s
  - Example
    - Detected: 137
    - Common: 100
    - 73% good detections
    - 12% of manual events

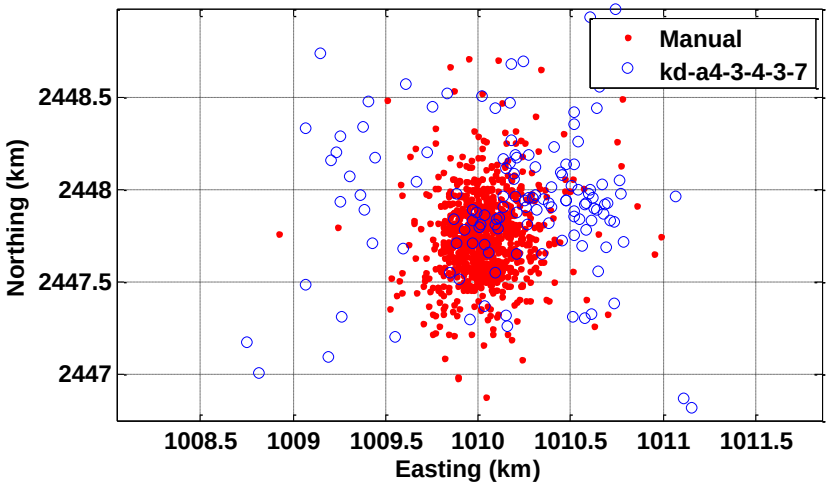


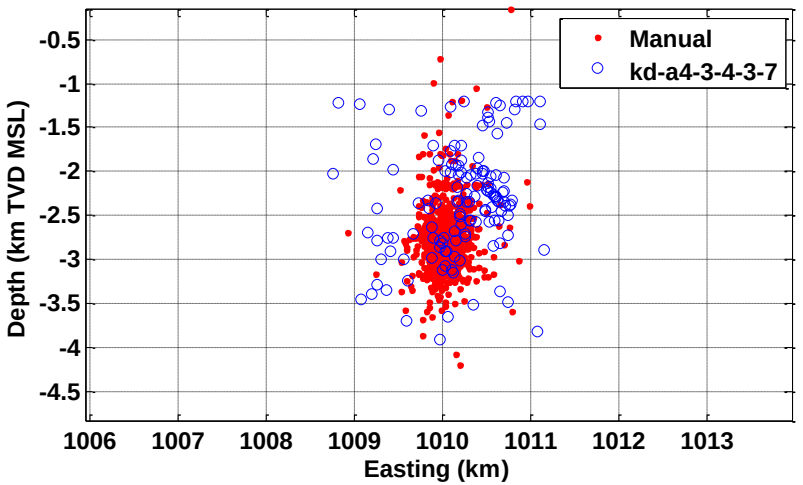
Event detection





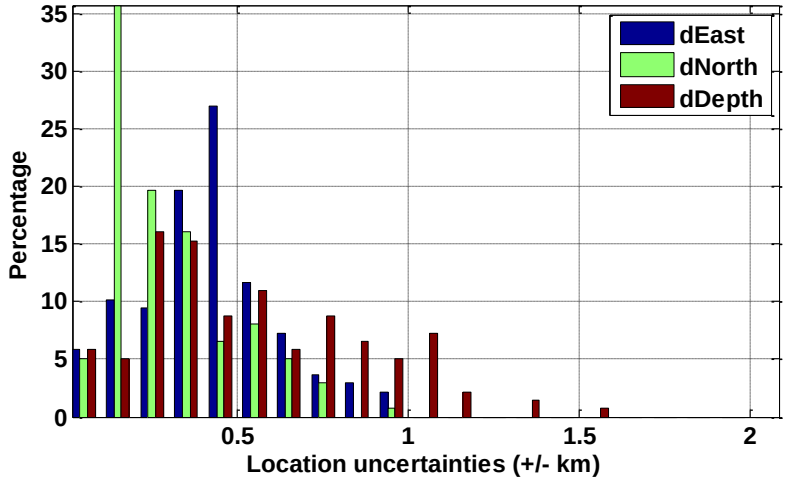
Location results





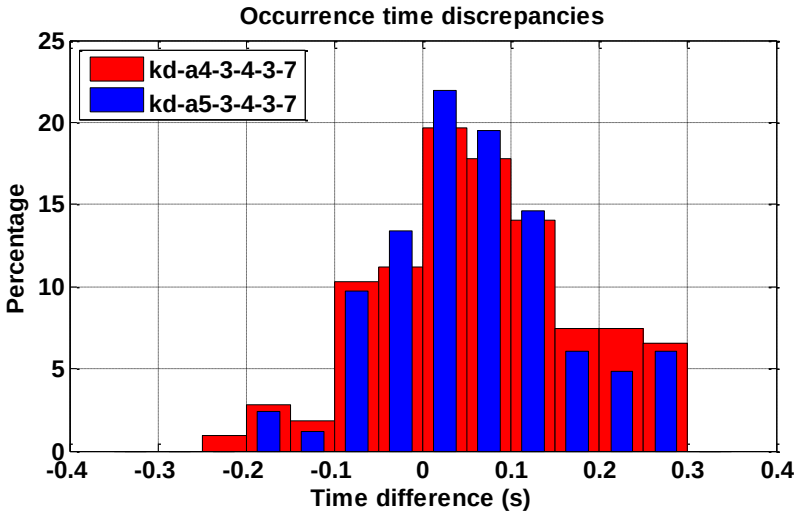
- Noticeable discrepancies with manual processing
- Waveloc location uncertainties
  - Median: 400 m / 200 m / 500 m

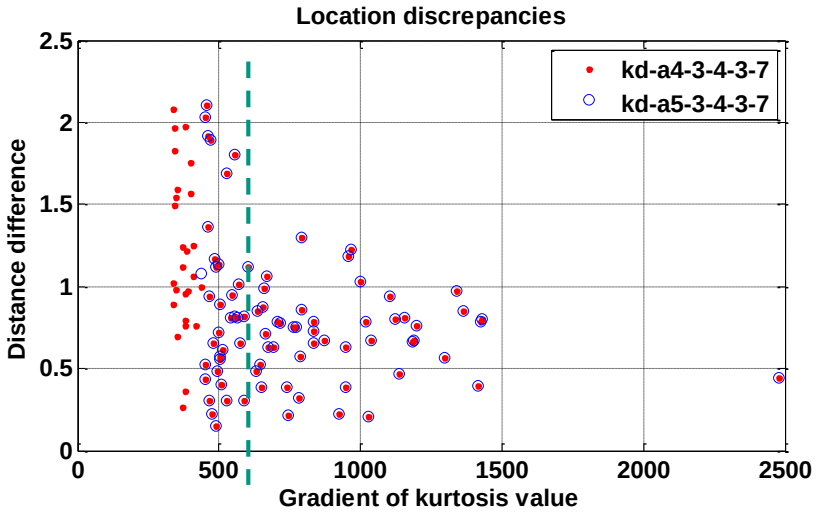
    East North Depth

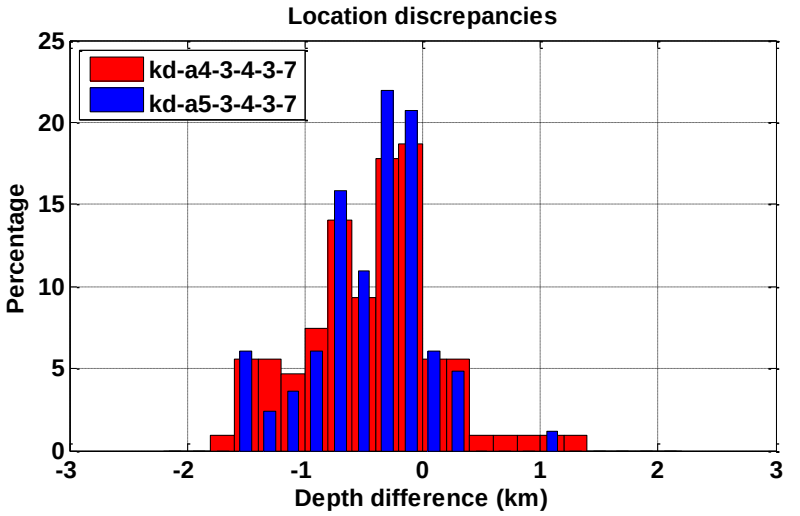


Detection & Location variations

- Case 1 (red)
  - Threshold = 4 x median
    - 73% good detections
    - 12% of manual events
- Case 2 (blue)
  - Threshold = 5 x median
    - 85% good detections
    - 10% of manual events







Conclusions & Perspectives

- No migration-based locations provided yet
- Automatic processing needs calibration
  - ⇒ Needs manual processing
  - ⇒ Needs time

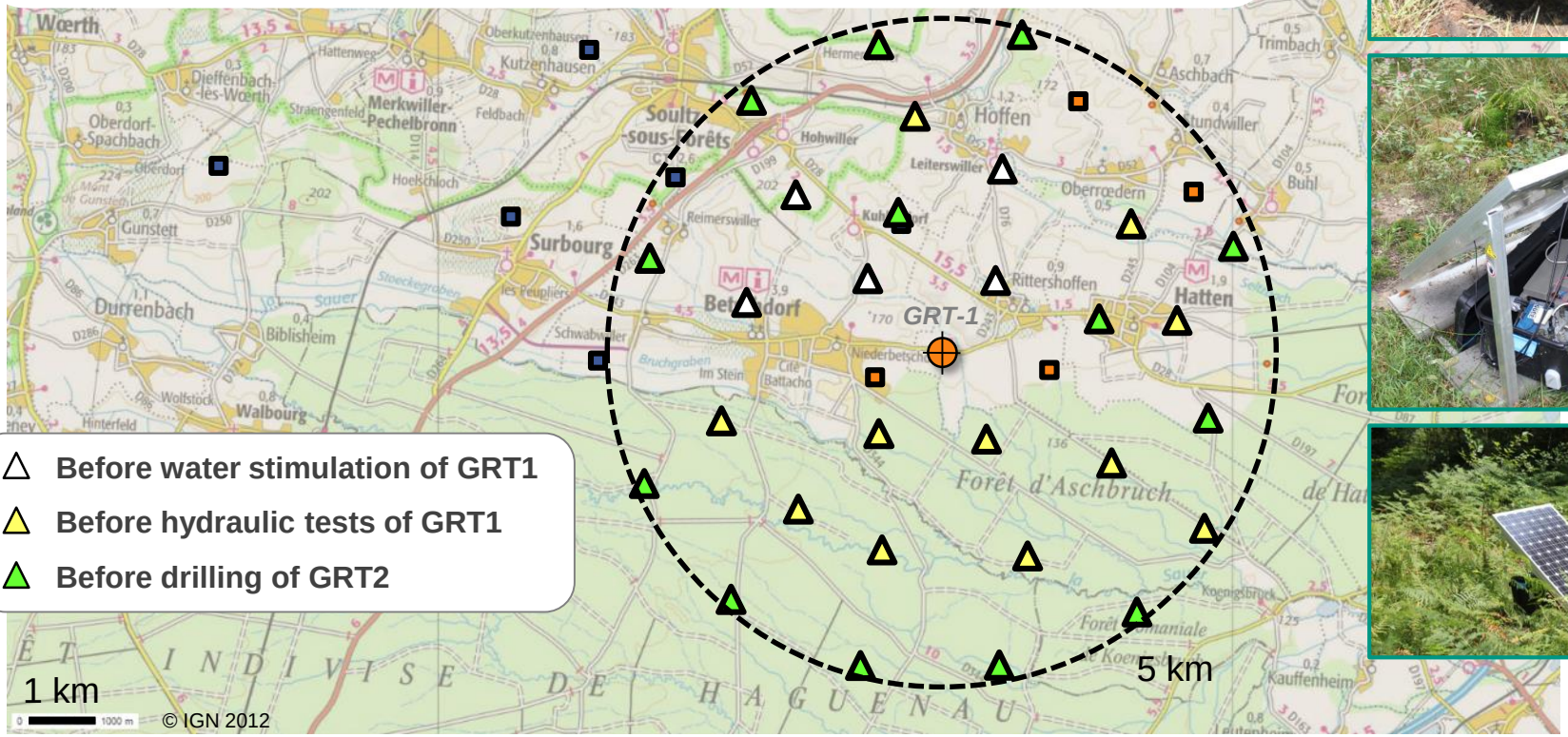
- Migration-based methods are strongly dependent on velocity models
  - Introduction of station correction?

- Application using a denser network

Seismic network before drilling of GRT2

Short period sensors

- 8 stations from Soultz permanent network (1C/3C)
- 4 stations from Rittershoffen permanent network (3C)
- △ 31 stations from KIT temporary network (3C)



△ **Before water stimulation of GRT1**

△ **Before hydraulic tests of GRT1**

△ **Before drilling of GRT2**

Thank you!