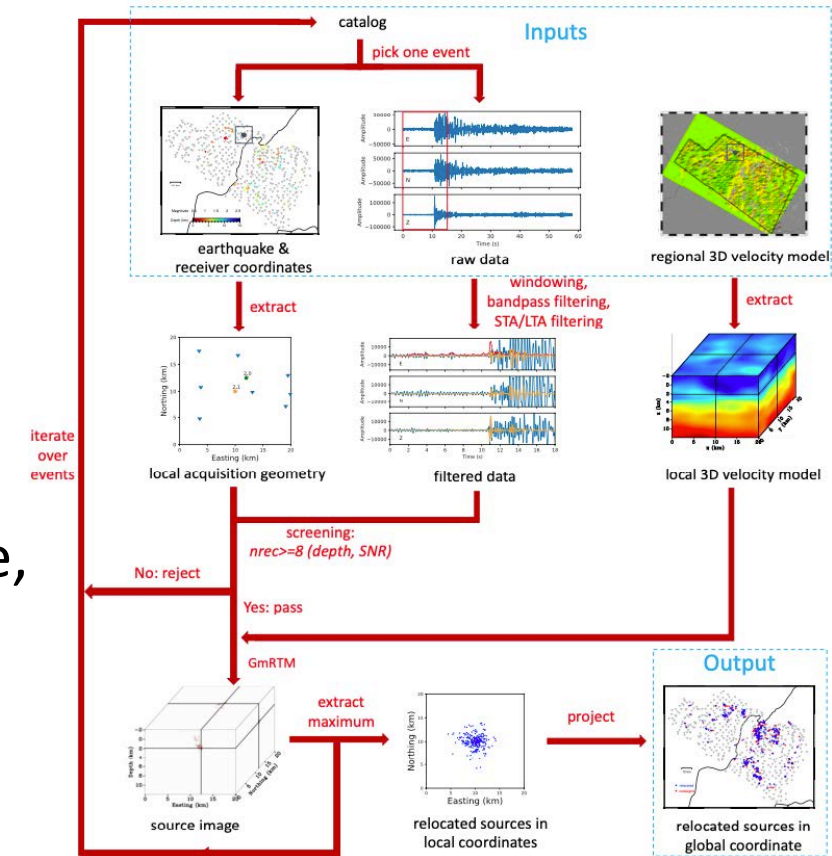


A “sliding box” automated earthquake relocation method based on GmRTM

Tong Bai

Postdoc Research Associate, EAPS

In collaboration with Zhendong Zhang, Malcolm C. A. White, Hongrui Qiu, Paul Williamson, and Nori Nakata



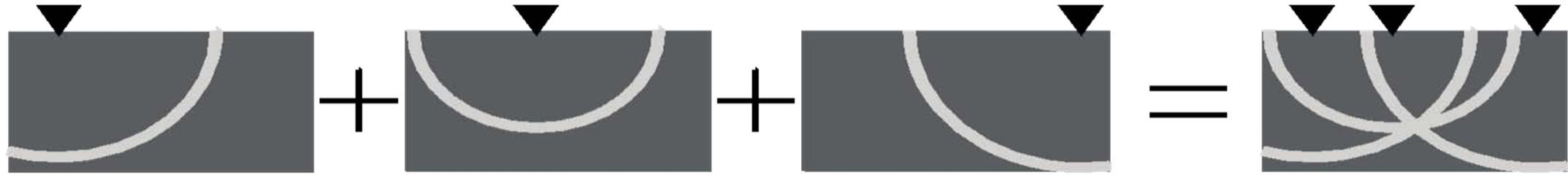
May 25, 2022



Migration-based imaging

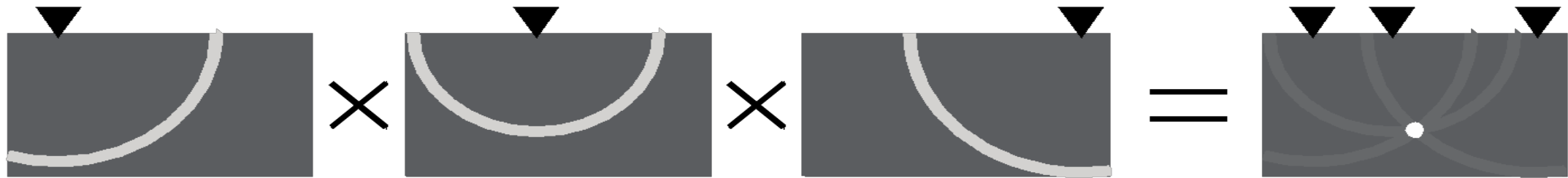
Arithmetic-mean RTM (locate & pick)

$$I_A(x, t) = \sum_i W_i(x, t)$$



Geometric-mean RTM (locate)

$$I_G(x) = \sum_t \prod_i W_i(x, t)$$



Nakata & Beroza, 2016



Elastic GmRTM

$$I_G^P(\mathbf{x}) = \int_t \prod_{i=1}^N \left[\vec{P}_i(\mathbf{x}, t) \cdot \vec{P}_i(\mathbf{x}, t) \right]$$

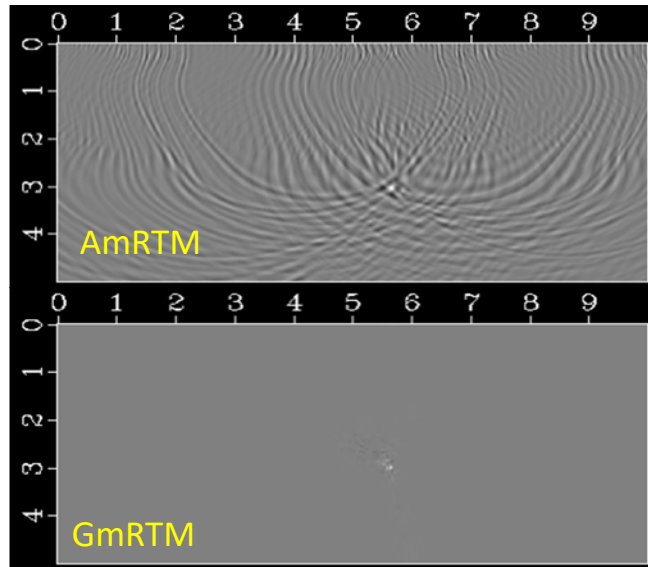
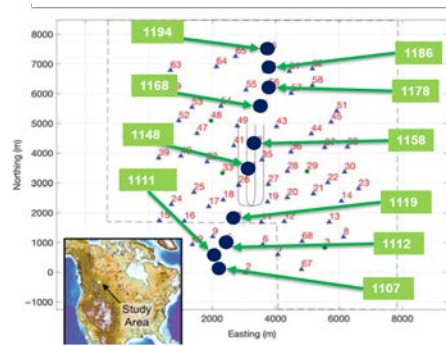
$$I_G^S(\mathbf{x}) = \int_t \prod_{i=1}^N \left[\vec{S}_i(\mathbf{x}, t) \cdot \vec{S}_i(\mathbf{x}, t) \right]$$

$$I_G^{PS}(\mathbf{x}) = \int_t \prod_{i=1}^N \left[\vec{P}_i(\mathbf{x}, t) \cdot \vec{S}_i(\mathbf{x}, t) \right]$$

Bai, Lyu, Li, Williamson,
and Nakata, 2022

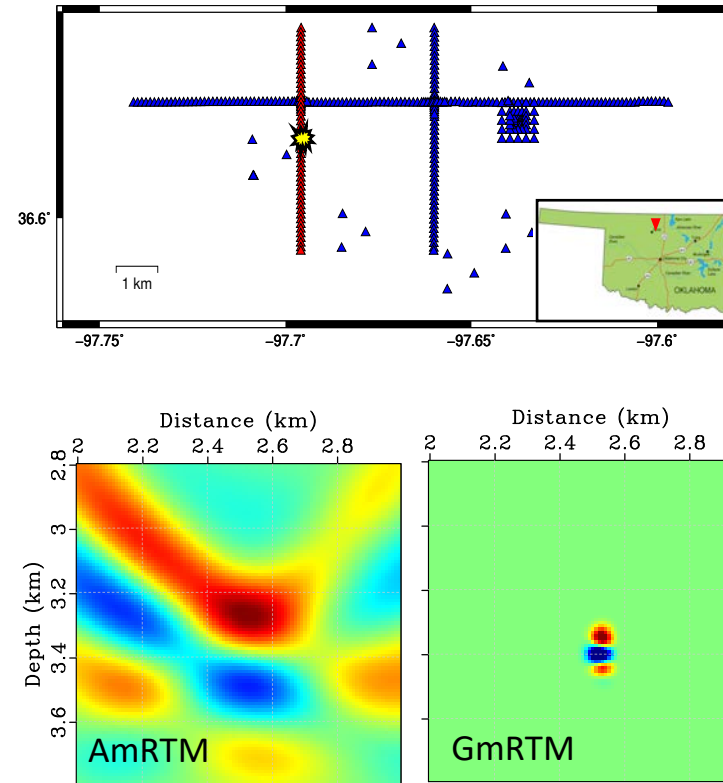


Applications



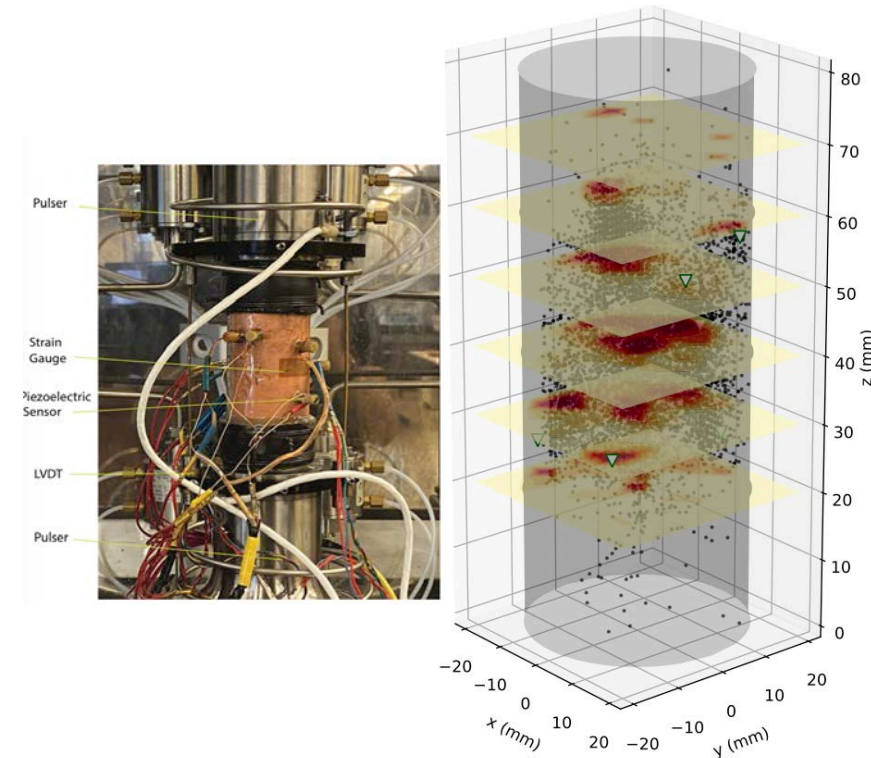
Hydro-fracturing

Bai, Lyu and Nakata, in prep



Induced seismicity

Bai, Lyu, Li, Williamson,
and Nakata, 2022



Acoustic emissions

Bai, Xing, Pec, and
Nakata, in prep

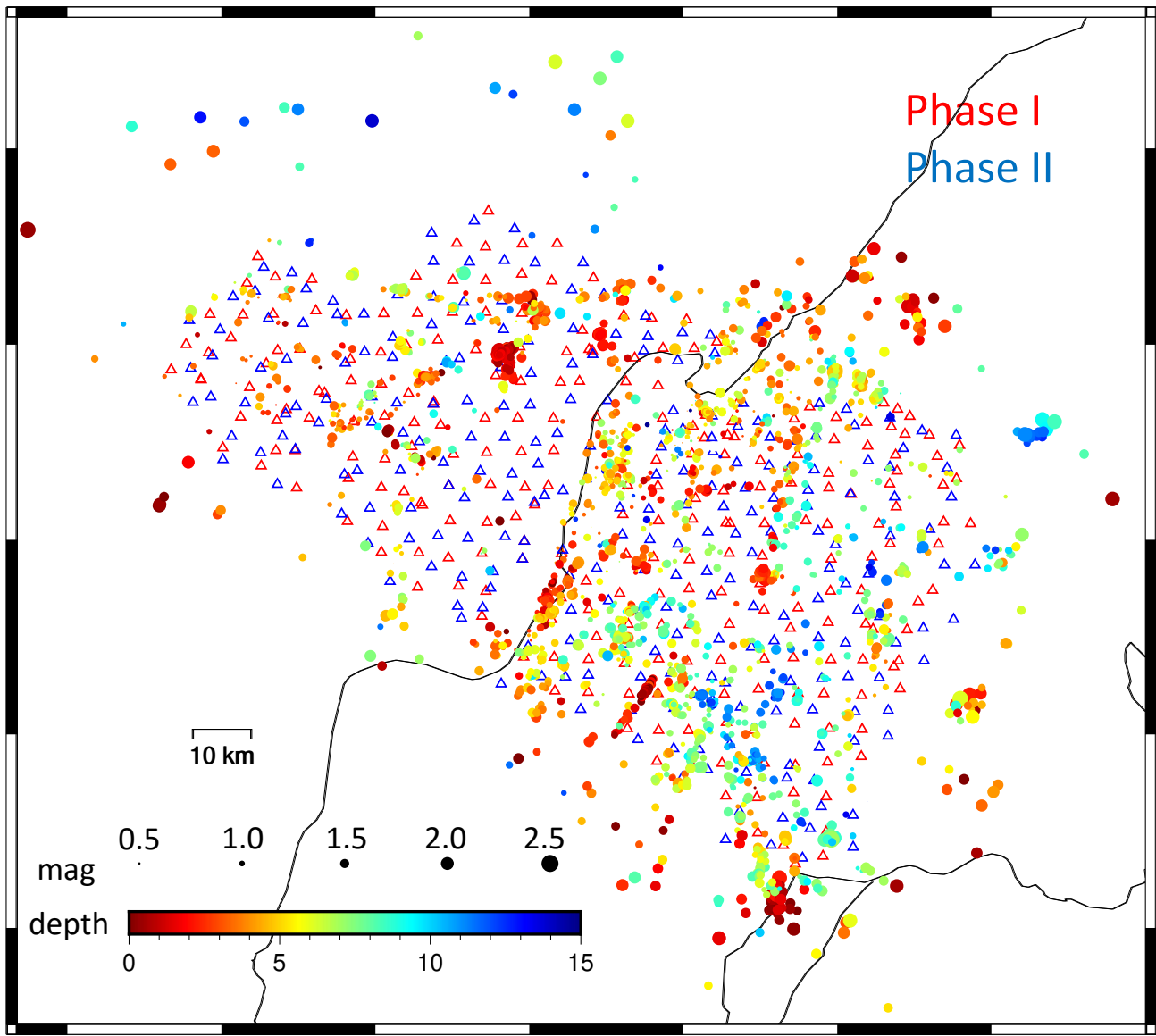
Dataset

array

- ~240 stations (3C) in each phase
- average distance ~5 km
- array size = 80 km * 100 km
- Recording for ~6 months

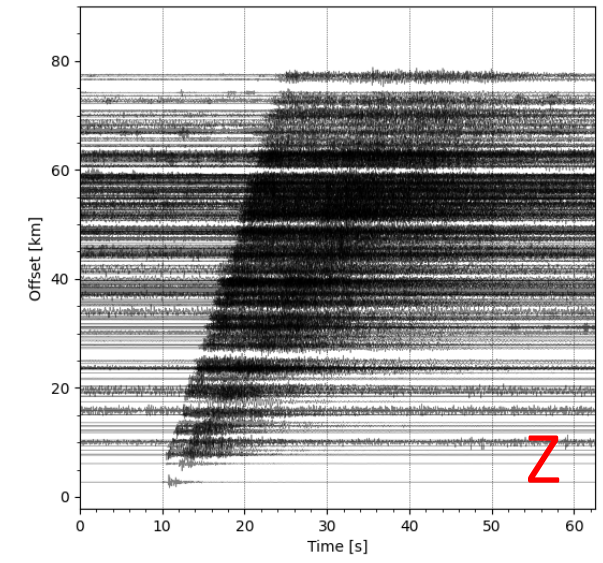
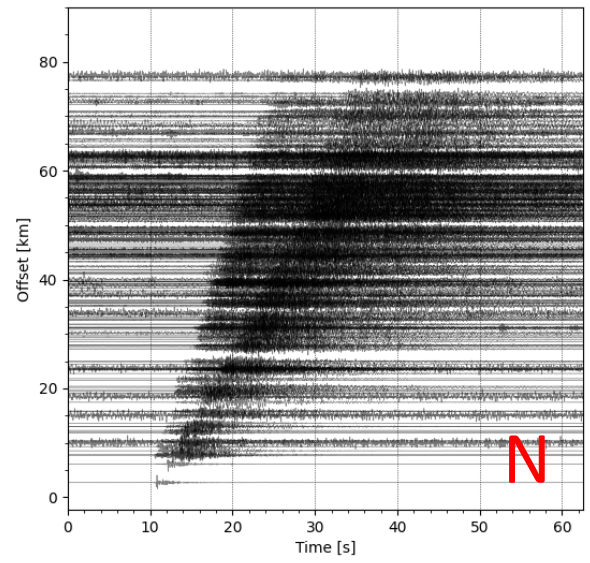
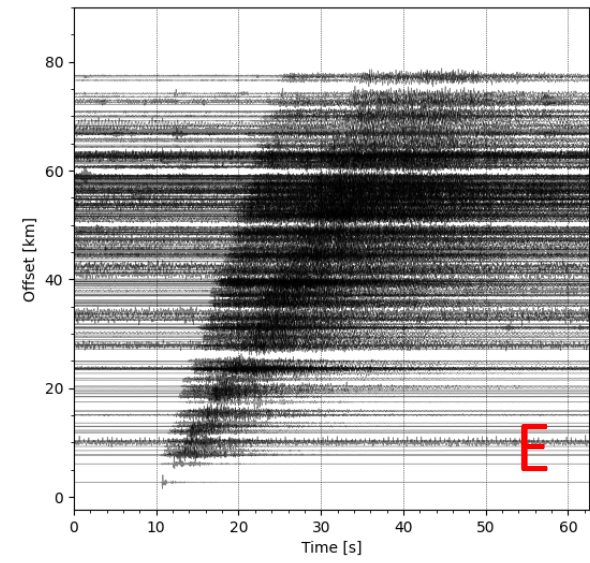
earthquakes

- 2607 events (traveltime-based)
- magnitude 0.5~2.5
- most depths <15 km

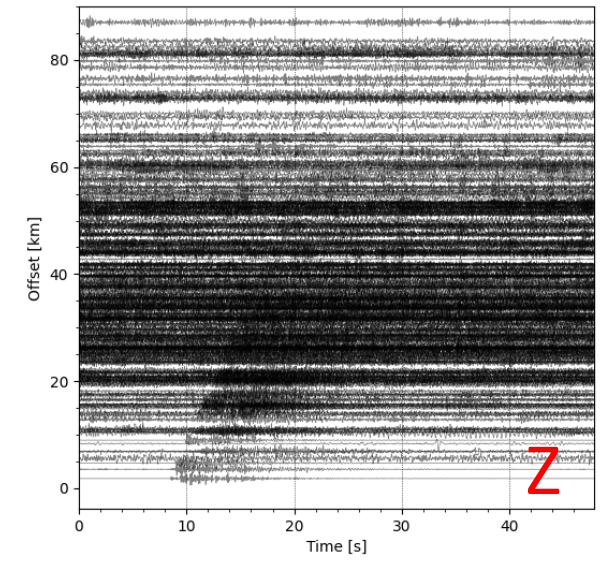
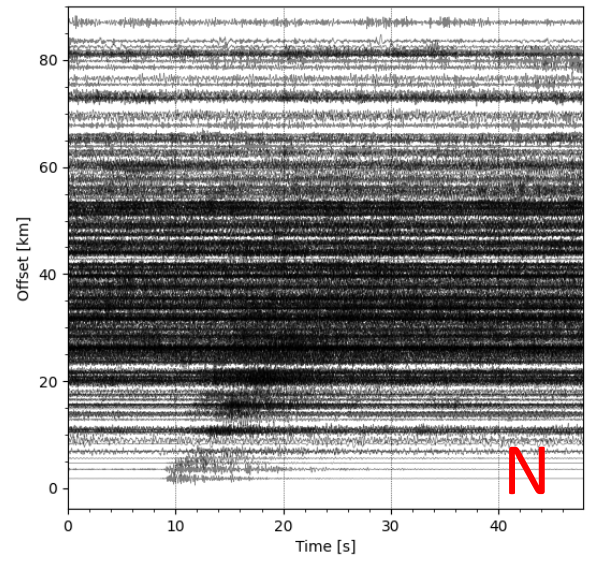
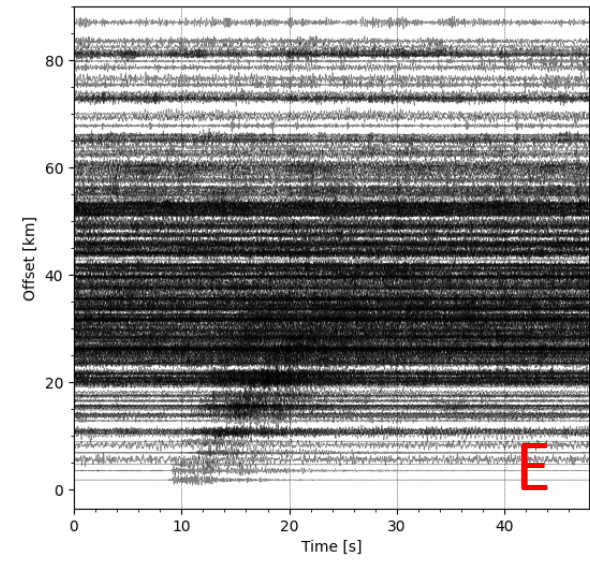


Sample data

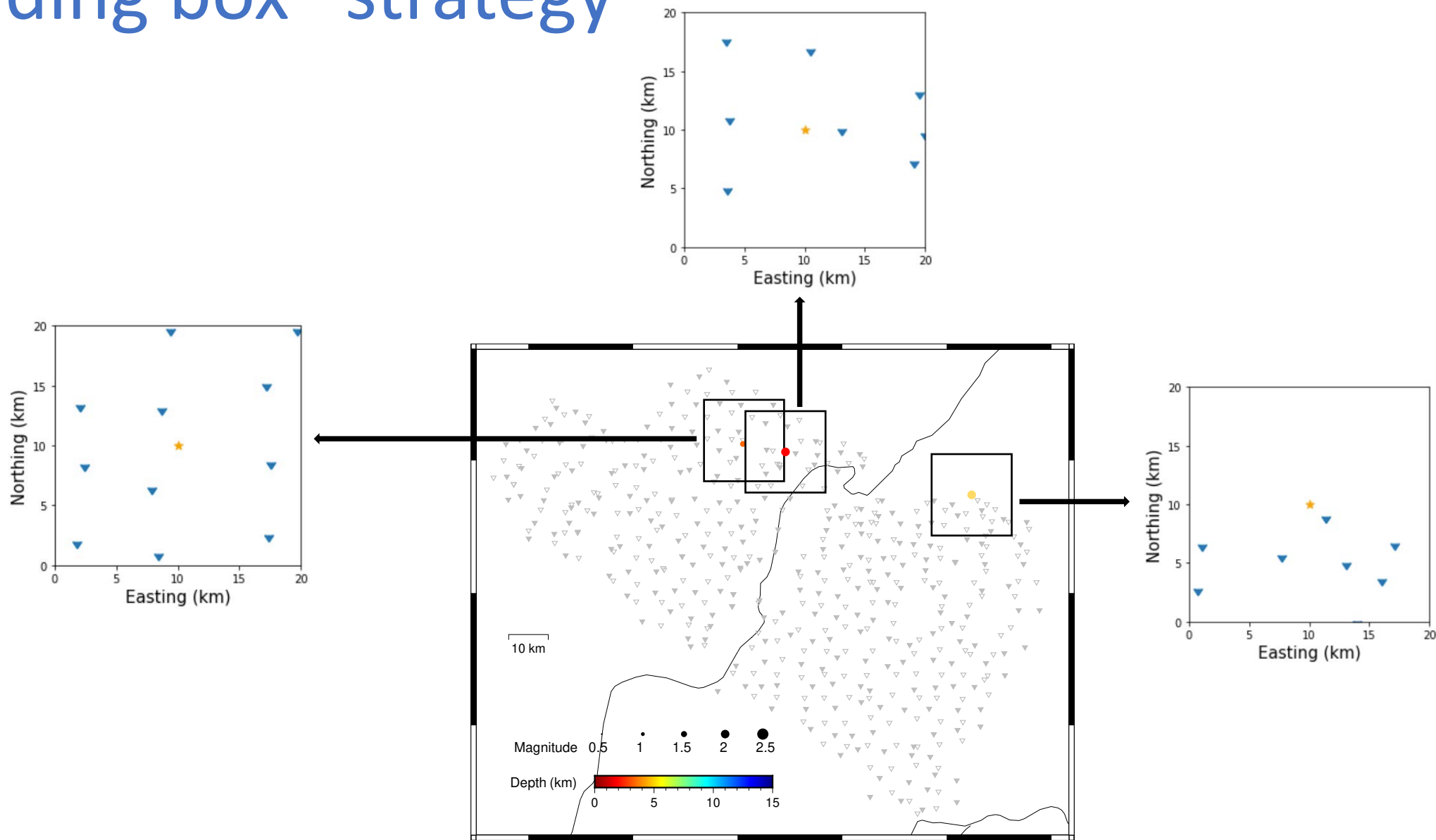
mag: 1.93
depth: 4.75 km



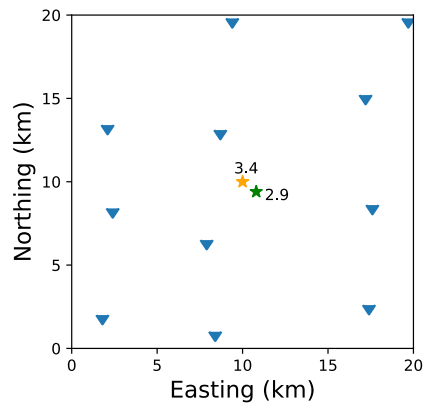
mag: 0.71
depth: 3.2 km



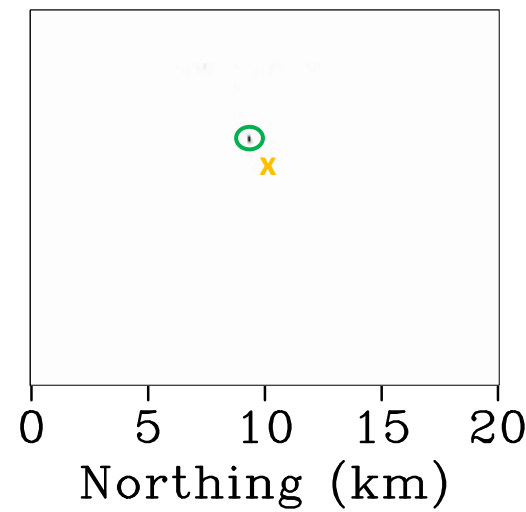
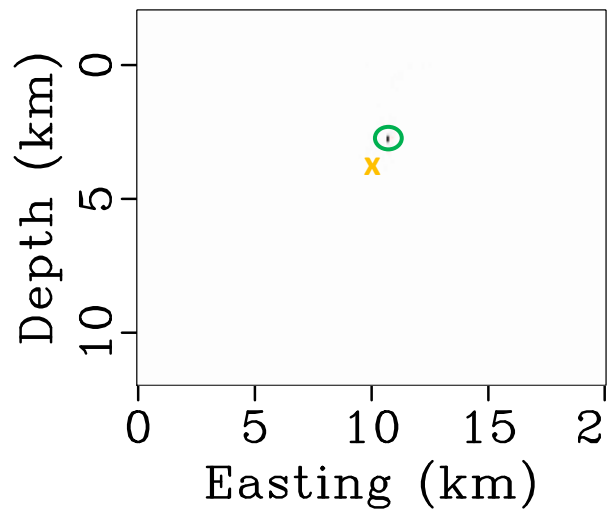
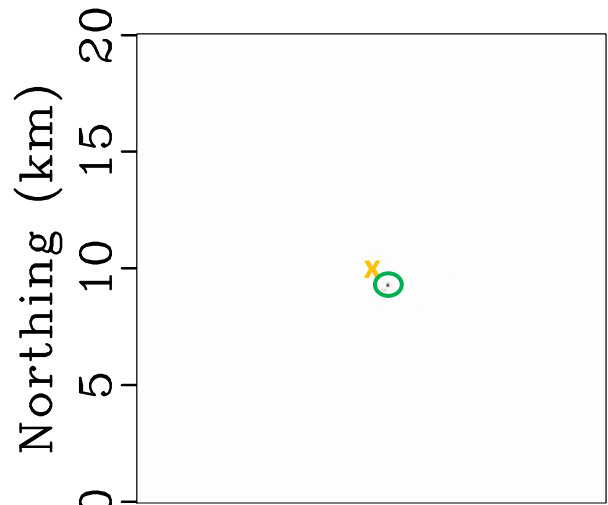
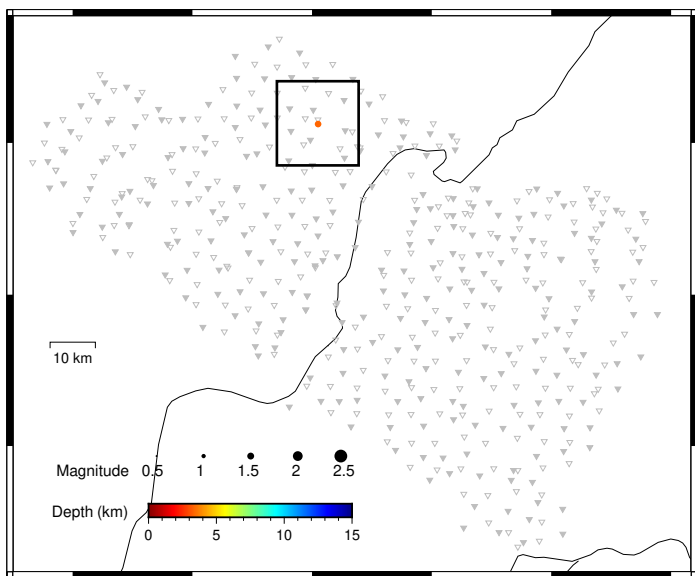
“Sliding box” strategy



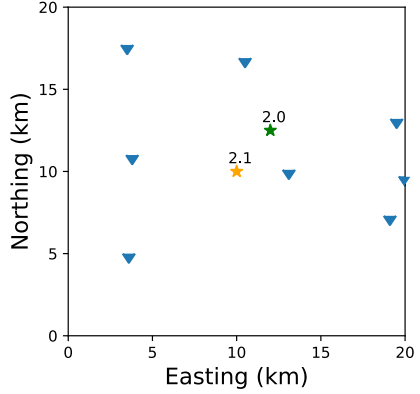
GmRTM images



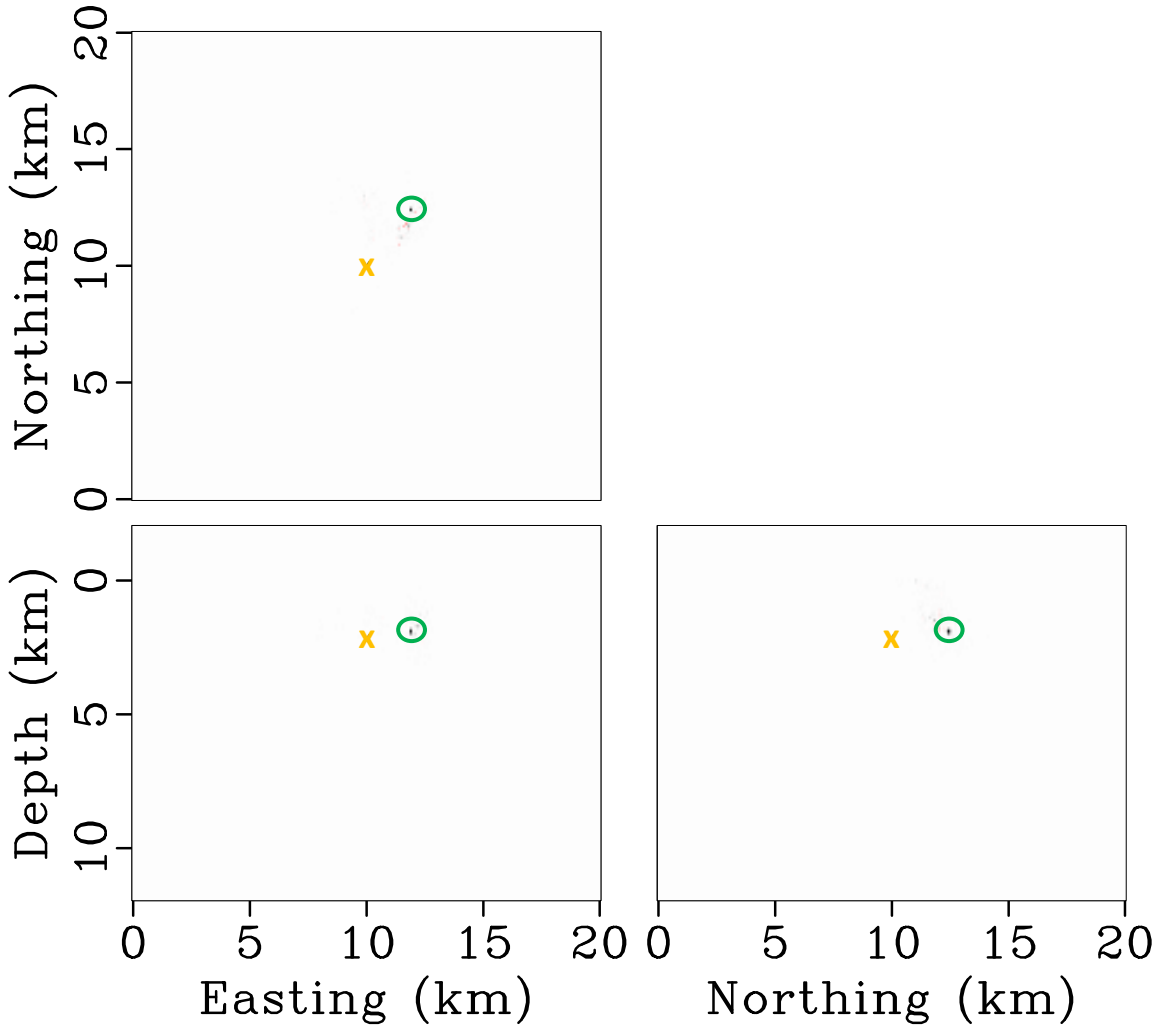
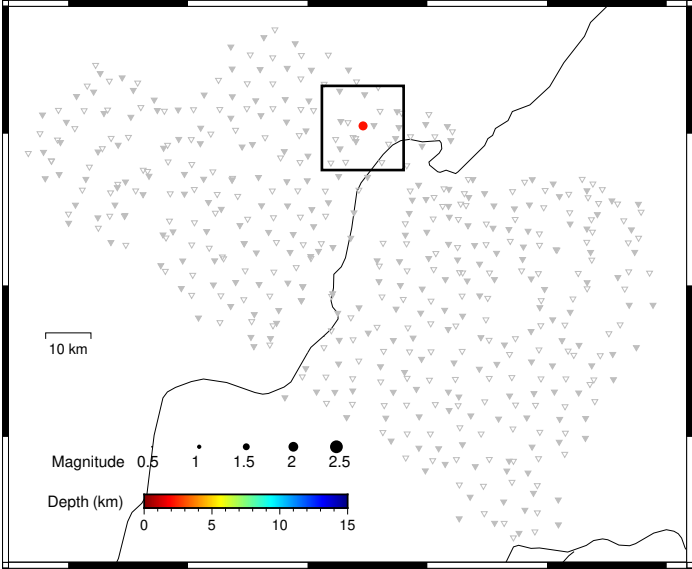
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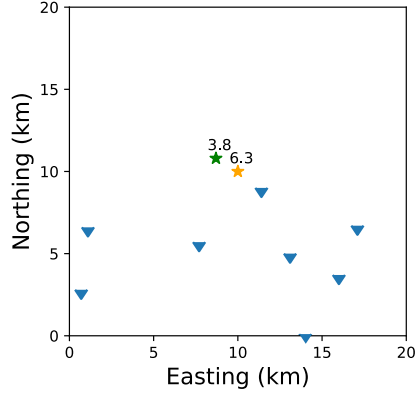
GmRTM images



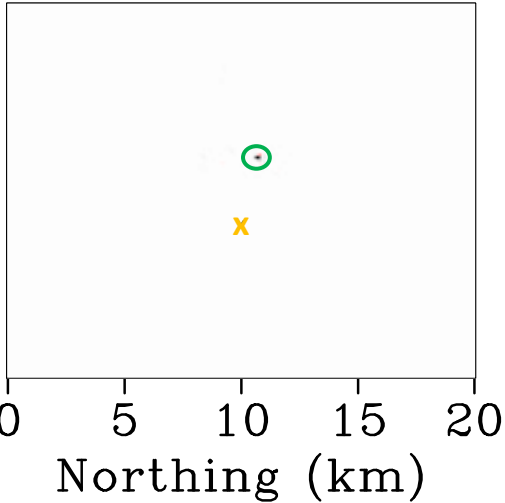
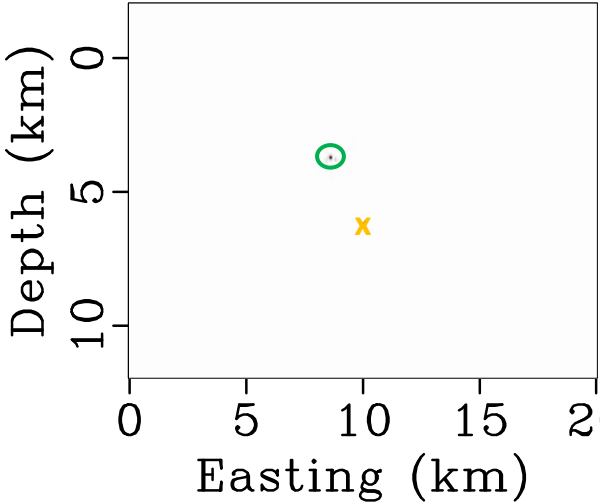
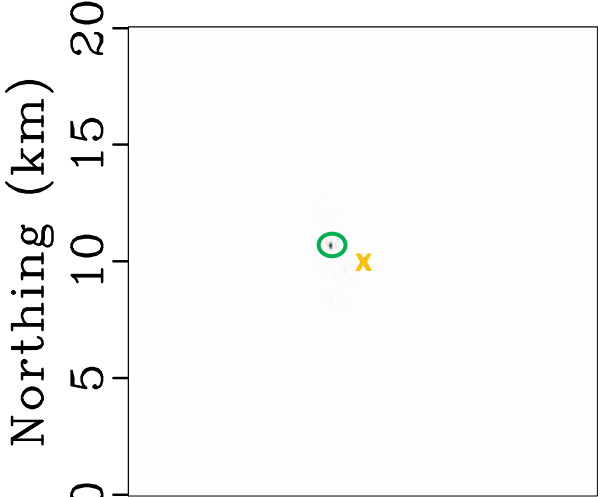
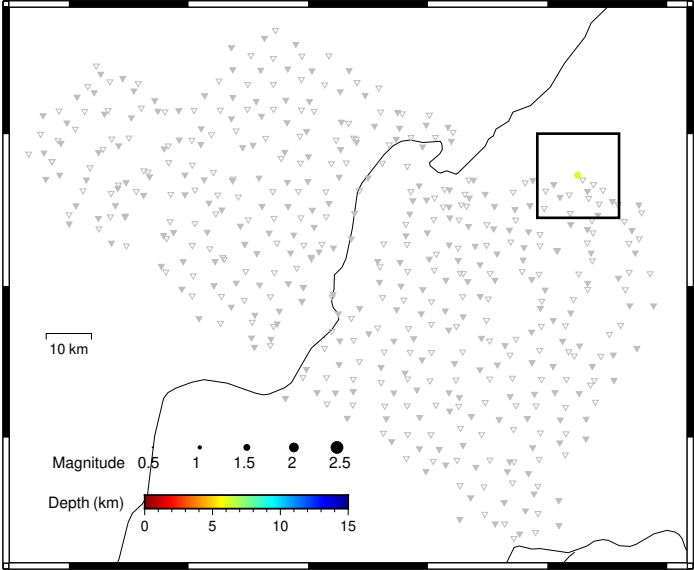
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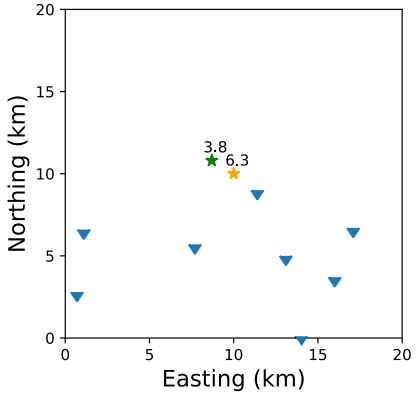
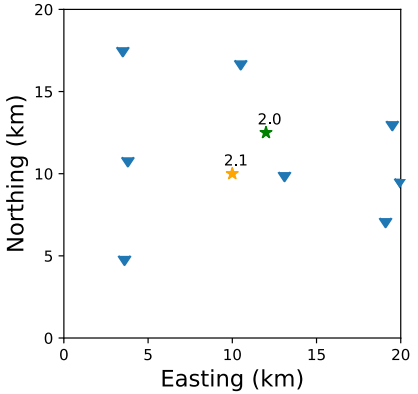
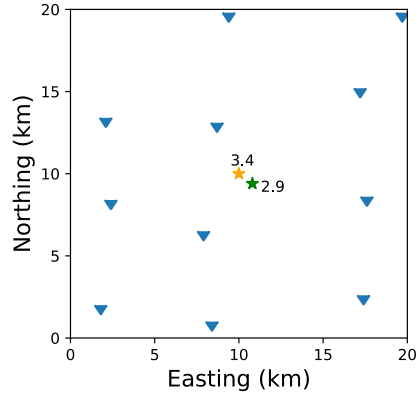
GmRTM images



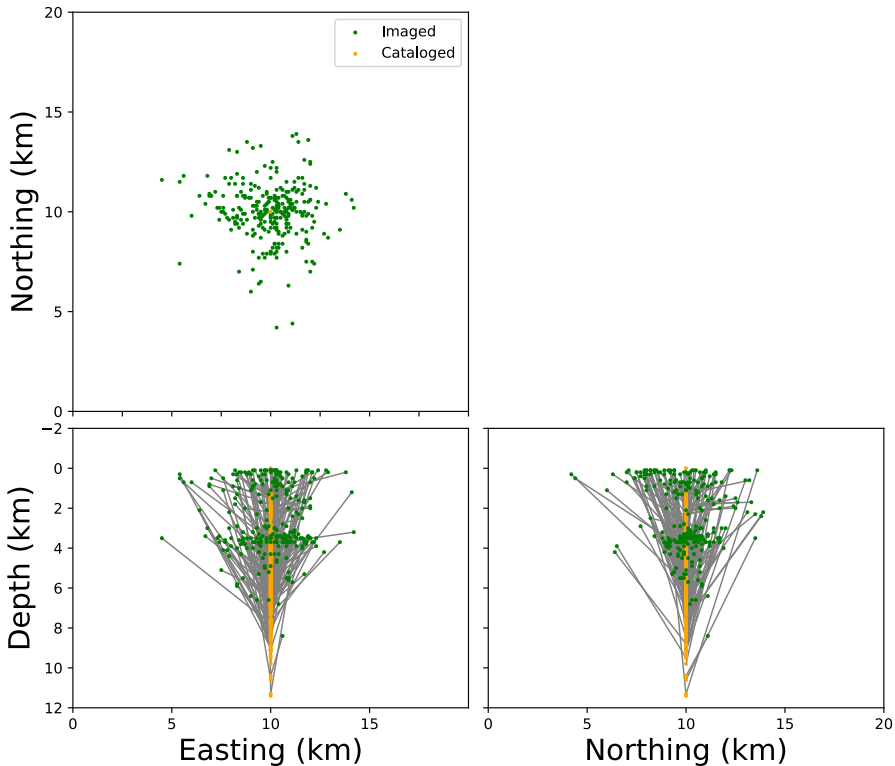
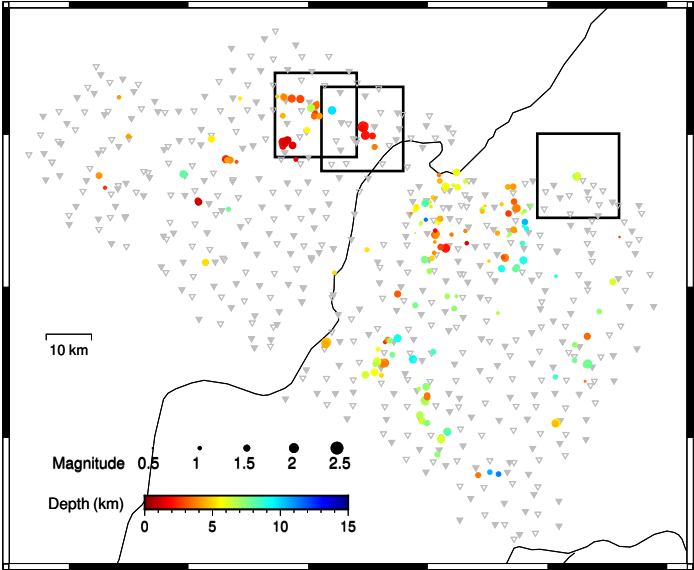
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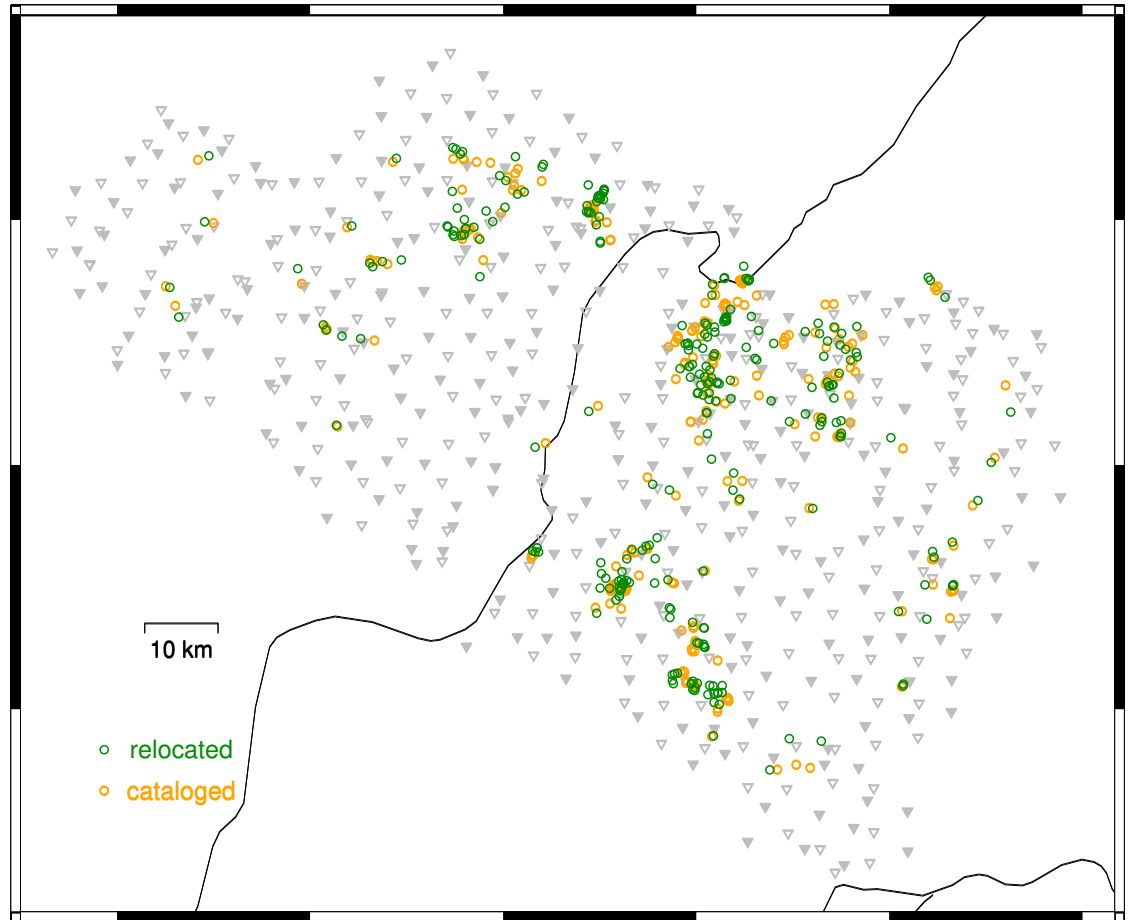
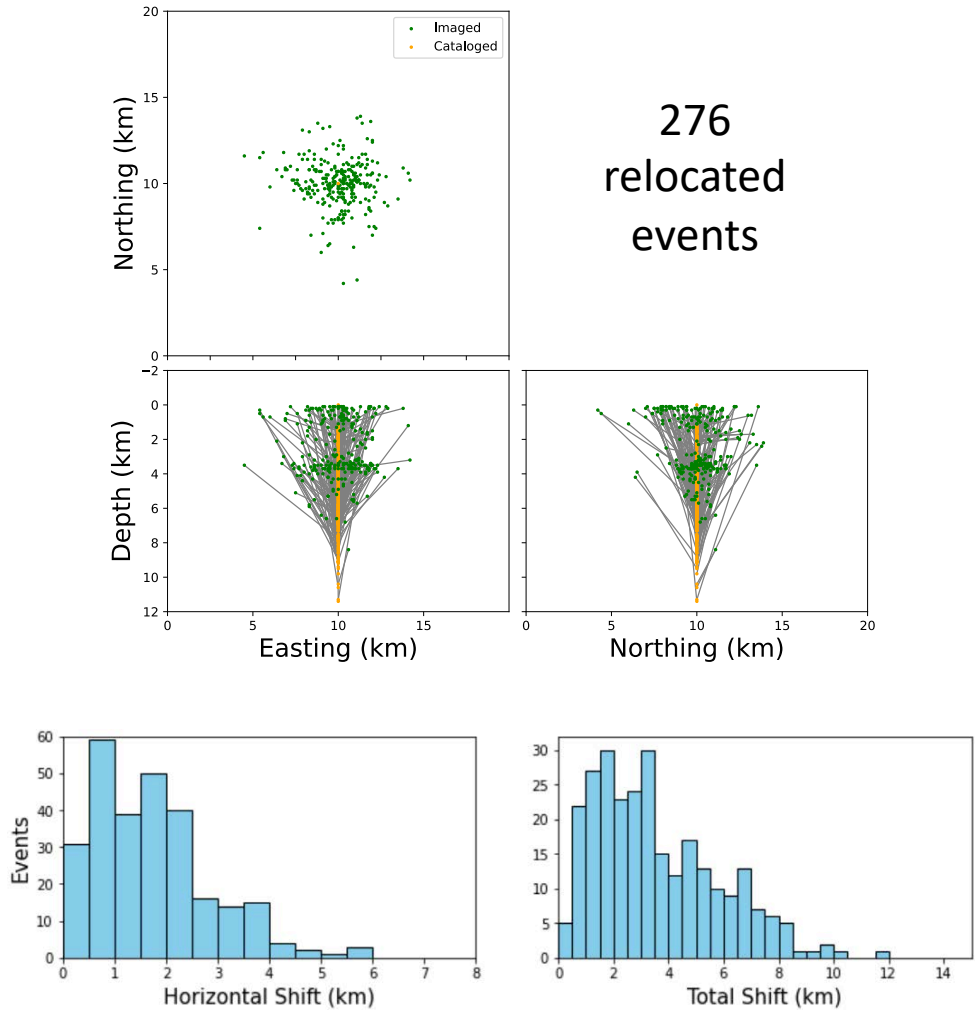
Locations in local coordinates



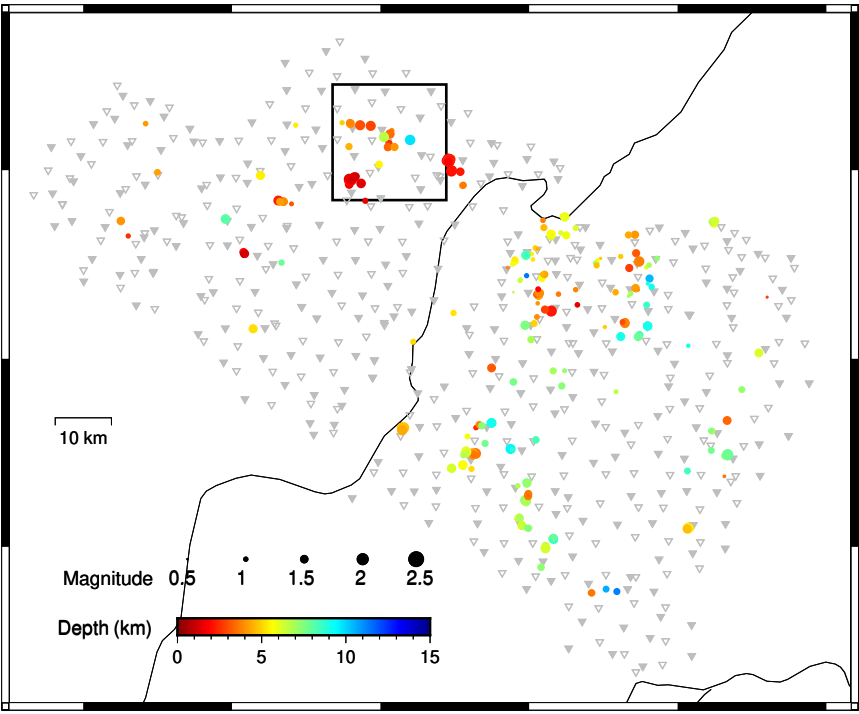
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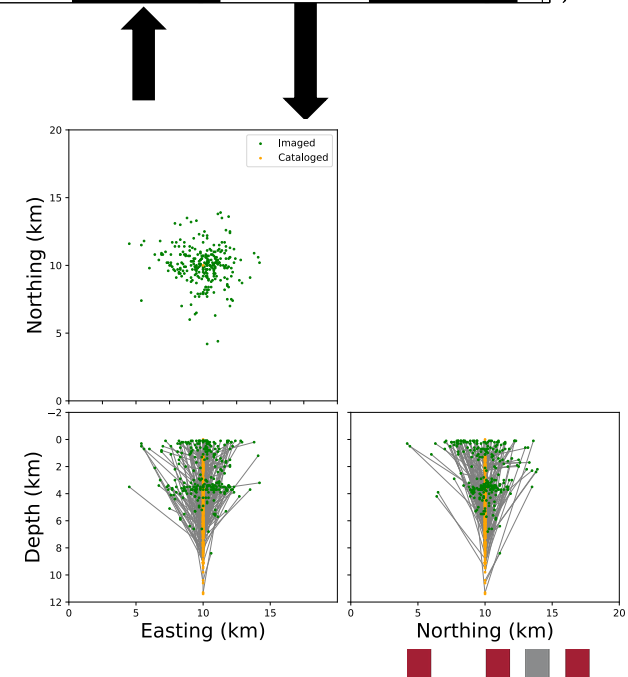
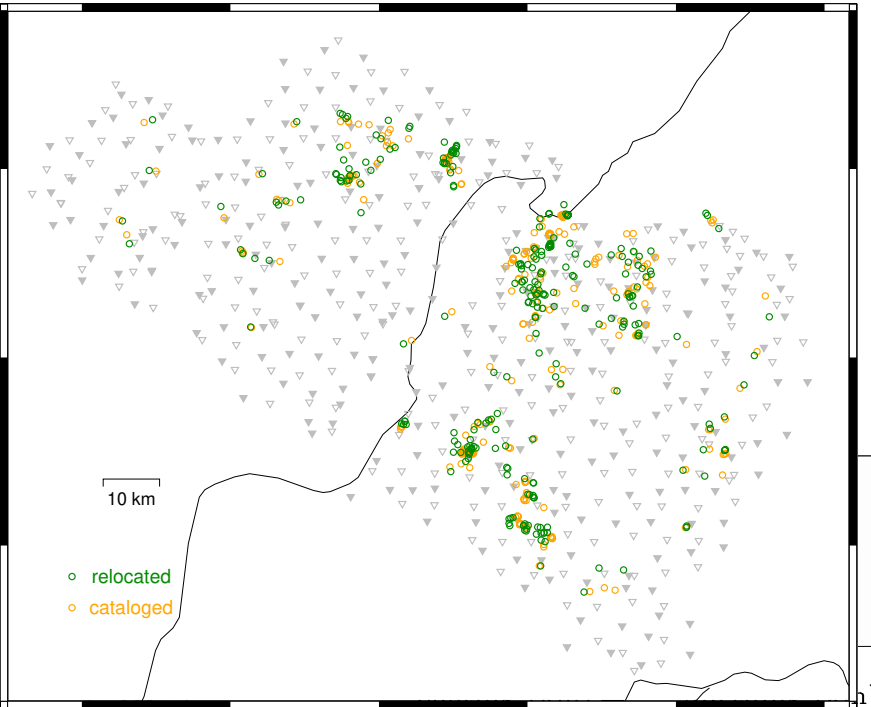
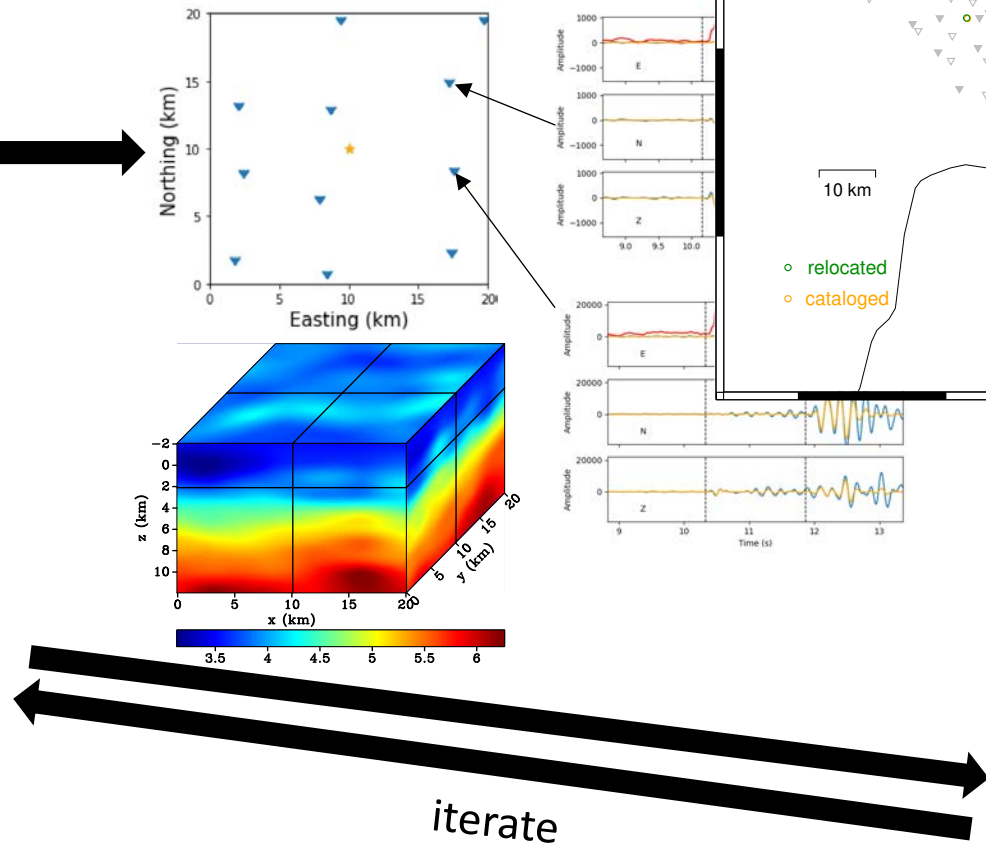
Locations in global coordinates



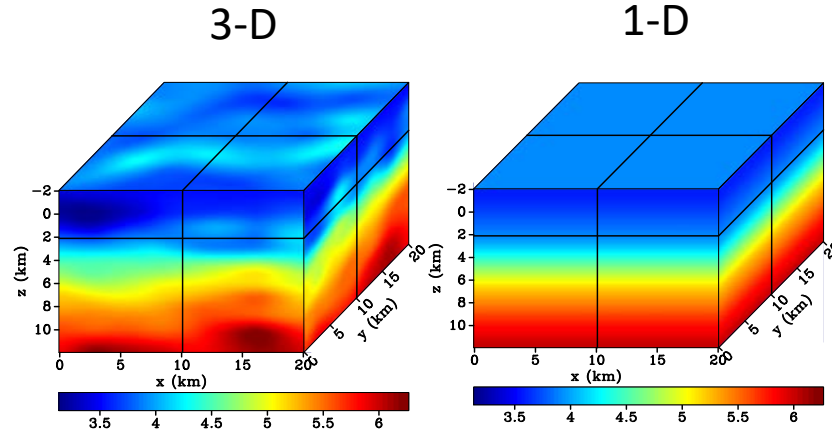
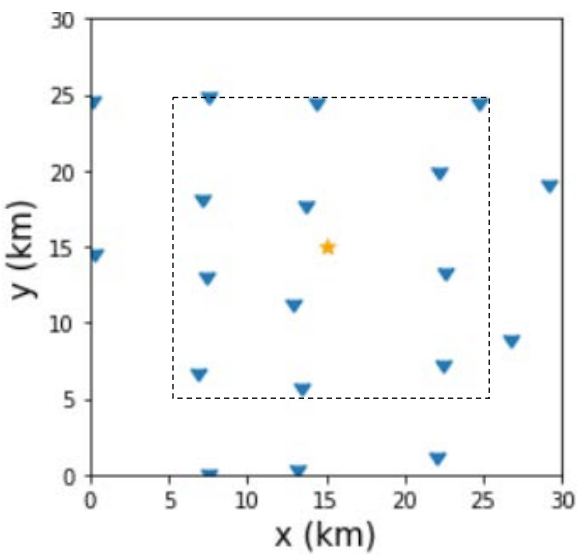
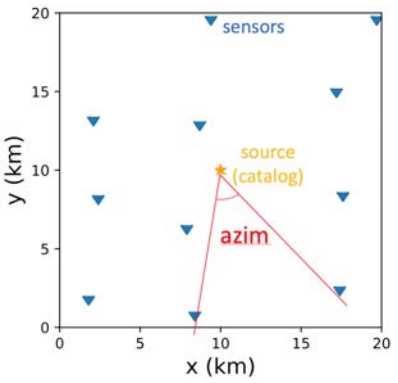
Automated relocation workflow



screening:
nrec (SNR>4)



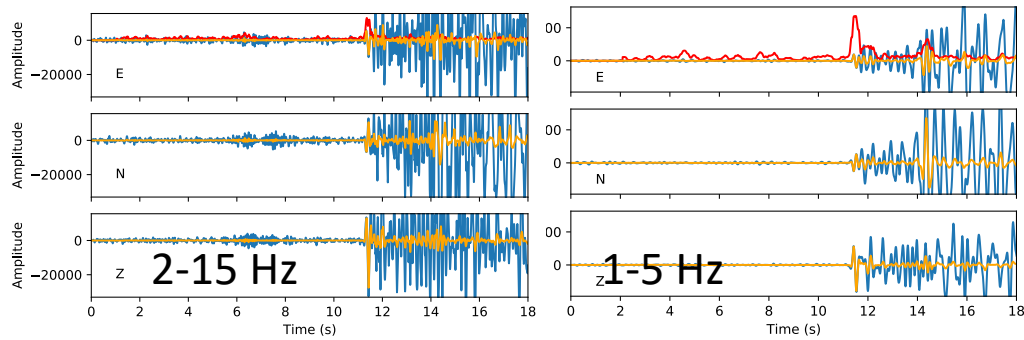
Sensitivity analysis



1. Acquisition geometry

2. Model dimension

3. Model accuracy



4. Frequency contents

5. Data quality

6. Imaging conditions: I_{PS} , I_P , I_S

7. Receiver grouping



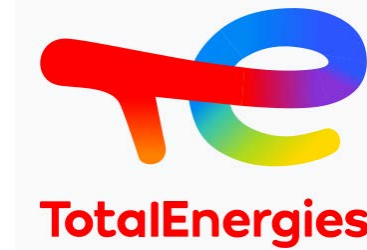
Summary

- Elastic GmRTM for high-resolution source imaging
- “sliding box” strategy
- STA/LTA filtering to suppress codas
- Screening: data SNR and receiver number
- Automated relocation for 276 events
- Sensitivity analysis



Acknowledgement

- TotalEnergies for support



- NEC cooperation for computational resources



- Yoshiyuki Kubo (NEC) for technique support

