Cross-validation of a GPU-based wave propagation solver and application to seismic waveform modeling of an M4.6 earthquake in Linthal, Switzerland

Celso Alvizuri*[12], Yury Alkhimenkov[23], Yury Podladchikov[23]

*[12]Norwegian Seismic Array, NORSAR
[2]University of Lausanne, Switzerland
[3]Swiss Geocomputing Centre, University of Lausanne, Switzerland

EGU22 – SM8.1 Physics-based earthquake modeling and engineering
Monday, May 21, 2022

UNIL | Université de Lausanne
Institut des sciences de la Terre

UNIL | Université de Lausanne
Swiss Geocomputing Centre

FNSNF
Fonds national suisse
Schweizerischer Nationalfonds
Fondo nazionale svizzero
Swiss National Science Foundation

NORSAR

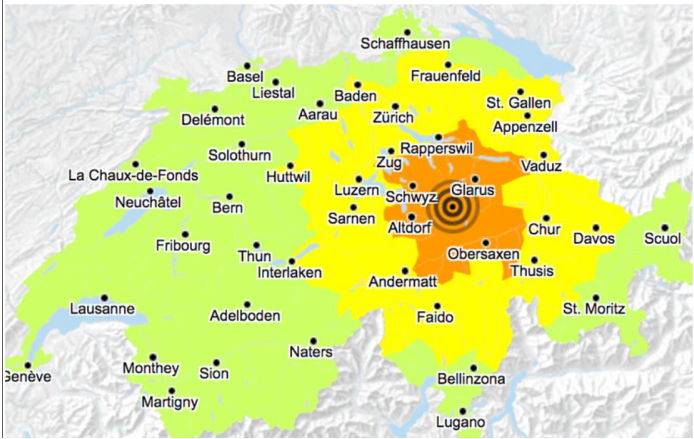
Outline

- The 6 March 2017 earthquake in Linthal, Switzerland, M4.6
- Earthquake source analysis and mechanism
- GPU-based wave propagation solver and synthetic seismograms
- Validation with synthetic seismograms, analytical solver

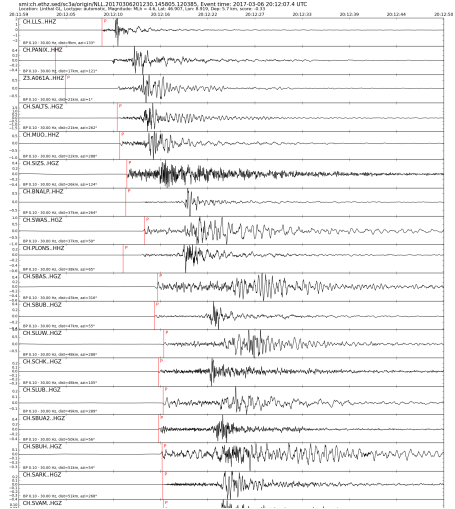
SWI swissinfo.ch

Swiss perspectives in 10 languages

Earthquake, 4.6, hits Switzerland



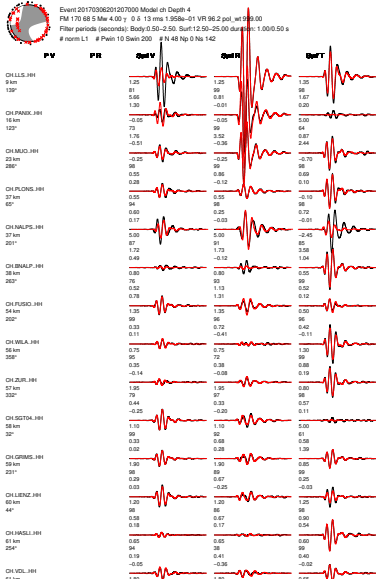
- 6 March 2017 Linthal, Glarus
- M4.6, depth 5.7 km
  Swiss Seismological Service
  www.seismo.ethz.ch

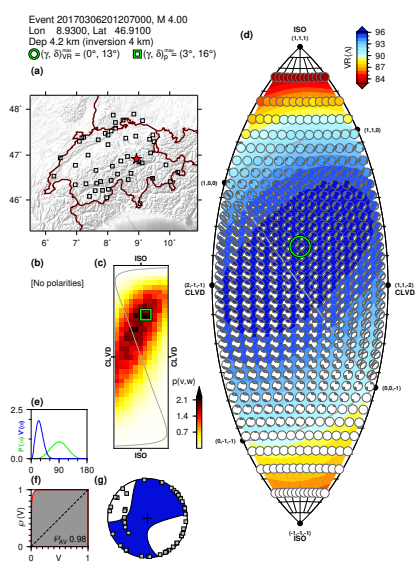


Earthquake source mechanism (moment tensor) and source-type analysis

Methodology:

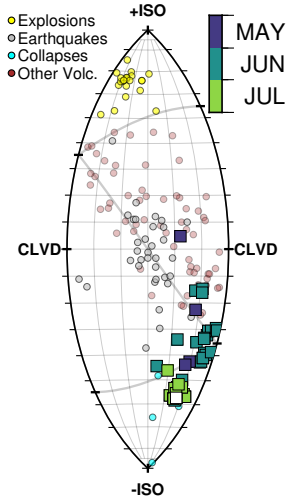
- Efficient search moment tensor space for best sol. (10M)
- Estimation of Full Moment Tensors, Including Uncertainties, for Nuclear Explosions, Volcanic Events, and Earthquakes (JGR Solid Earth, Alvizuri et al., 2018)
- Seismic waveforms
- Moment tensors
- Source-types (lune diagram)





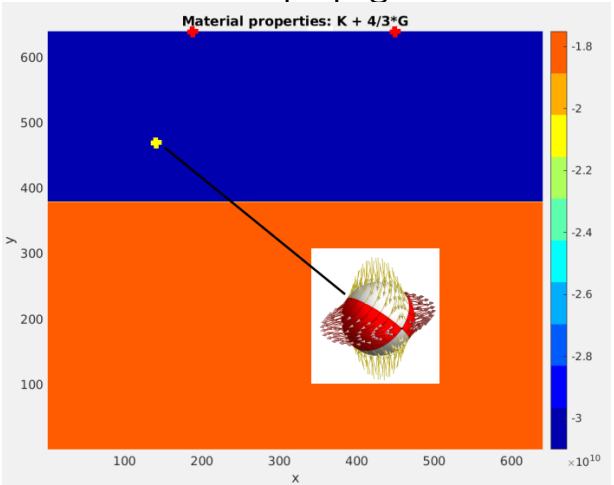
Earthquakes → Moment tensors → Source-types → Classification

- Explosions, earthquakes, collapses, cracks, CLVD, etc.
- Different earthquakes map into different regions of lune (source-type diagram)
- **Earthquake source classification**
- Earthquakes with space, time

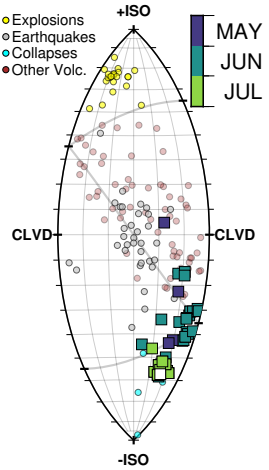


Alvizuri et al., EPSL, 2021

GPU based wave propagation solver and source-type analysis



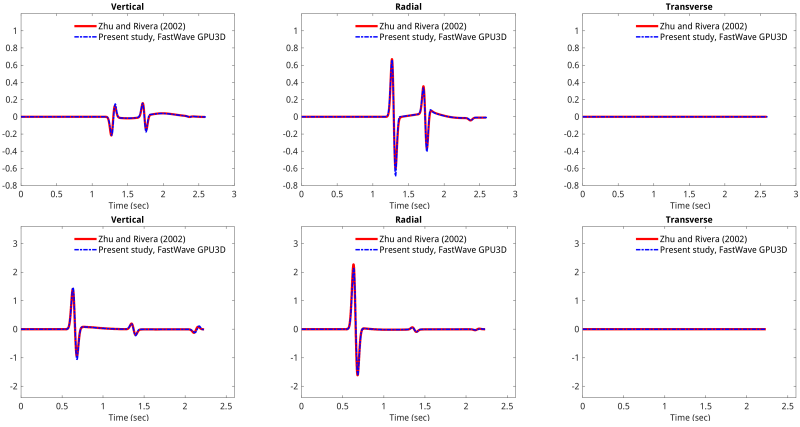
Yury Alkhimenkov



Alvizuri et al., EPSL, 2021

Cross validation of a hydro-mechanical GPU solver for anisotropic, porous media and application to seismic waveform modeling, Geophys. J. Int.(in prep.). Alvizuri, C., Alkhimenkov, Y. & Podladchikov, Y. , 2022.

Synthetic waveforms for a spherical source, eg a nuclear explosion

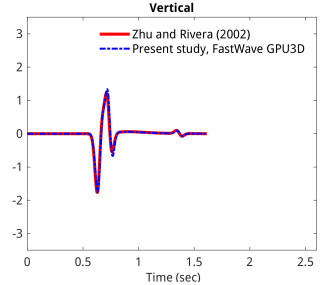


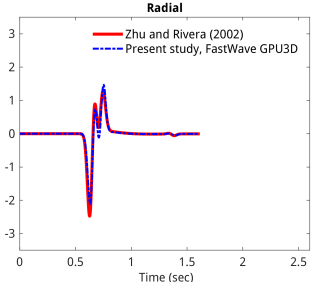
A wave propagation solver

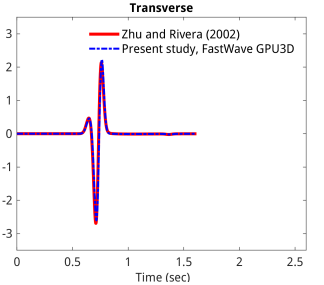
- Efficient generation of synthetic seismograms
- Earthquake nucleation with moment tensors and spontaneous earthquakes
- GPU based, efficient, CUDA, C++, Matlab interface

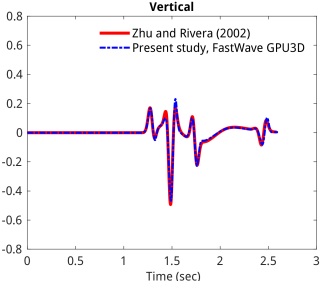
Resolving wave propagation in anisotropic poroelastic media using graphical processing units (GPUs). Alkhimenkov et al., 2021, JGR Solid Earth

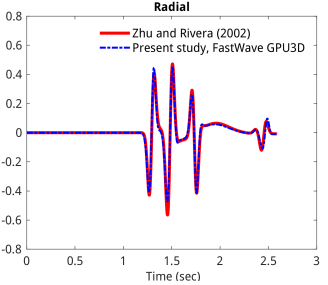
Synthetic waveforms for a double-couple earthquake

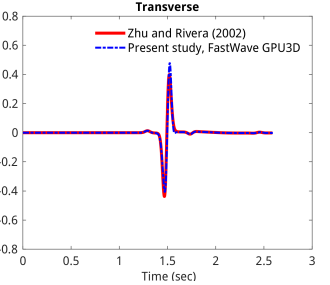






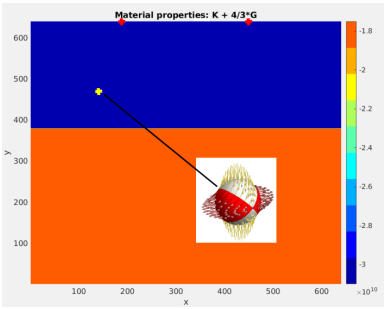


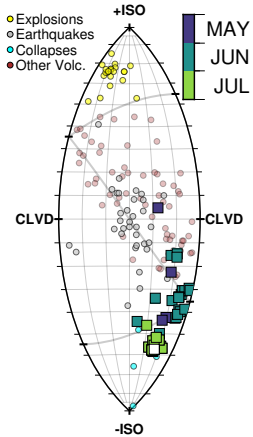




Takeaways

- An efficient wave propagation solver
- Anisotropic poroelastic media, coupled hydro-mechanical
- Earthquake nucleation
  - moment tensors
  - spontaneous earthquakes
- Waveform generation
- Source-type analysis
- **Earthquake nucleation and classification**





Thank you for your attention

References

Alkhimenkov, Y., Räss, L., Khakimova, L., Quintal, B., & Podladchikov, Y., 2021. Resolving wave propagation in anisotropic poroelastic media using graphical processing units (CPUs), *J. Geophys. Res.*, **126**, doi:10.1029/2020JB021175.

Alvizuri, C., Silwal, V., Krischer, L., & Tape, C., 2018. Estimation of full moment tensors, including uncertainties, for nuclear explosions, volcanic events, and earthquakes, *J. Geophys. Res. Solid Earth*, **123**, 5099–5119, doi:10.1029/2017JB015325.

Alvizuri, C., Matoza, R. S., & Okubo, P. G., 2021. Earthquake collapse mechanisms and periodic, migrating seismicity during the 2018 summit collapse at Kīlauea caldera, *Earth Planet. Sci. Lett.*, **562**, 116819, doi:10.1016/j.epsl.2021.116819.

Alvizuri, C., Alkhimenkov, Y., & Podladchikov, Y., 2022. Cross validation of a hydro-mechanical gpu solver for anisotropic, porous media and application to seismic waveform modeling, *Geophys. J. Int.*(in prep.).