We develop a scalable workflow for parallel earthquake source inversion employing Bayesian methods.

Earthquake simulations with SeisSol

SeisSol (https://seissol.org) is a well-established simulation software for earthquake source dynamics and seismic wave propagation. SeisSol solves the hyperbolic PDE

\[ \frac{\partial q}{\partial t} + A \frac{\partial q}{\partial x} + B \frac{\partial q}{\partial y} + C \frac{\partial q}{\partial z} = Eq \]

Key features

- Realistic Materials: anisotropic elastic, isotropic elastic, poroelastic and viscoelastic materials with optional plastic deformation
- Physics based sources: dynamic rupture, rate-and-state friction
- Geometric flexibility: based on mesh partitioning

Performance of the Generalized Metropolis-Hastings algorithm

We test the performance of the GMH algorithm on a simple ODE test case with two unknown model parameters. We vary the number of simulations to 1000 samples. The acceptance ratio increases with \( N \). \( K \) \(<\ N \) generates more independent samples. We use \( K = N \) for small \( N \) for best ESS per time ratio.

Effective sample size (ESS) characterizes how many (approximately) independent samples have been drawn.

Finding the source position of the LOH1 scenario with GMH sampling

Model setup
- Unknown source position \( c \), \( \theta \), \( g \), \( h \)
- Ground truth \( (0, 0, 2000) \)
- Data \( y \): semianalytic solution of receiver seismograms

Implementation
- Use SeisSol with fused simulation, \( N = 8 \).
- Fused GMH kernel patch of MUQ library [2].
- Compare result with data \( y \) using \( | \cdot | \) norm.
- Runtime 21 h on 32 nodes to collect 640 samples.

Results
- \( K \) slightly off with significant offset in \( x/y \) direction: \( (-471, 733, 2232) \).
- Receiver 2 and 4 match well.
- Receiver 1 and 3 are troubled in particular \( v_3 \).
- Acceptance ratio = 11\% , ESS = 8

Upcoming work
- Improve acceptance ratio and ESS.
- More unknowns e.g. source orientation, frequency

Realistic scenario: dynamic rupture, topography

References

