3 WBM in random heterogeneous media

3.1 Accuracy test on numerical differentiation

- left: highly varying input signal regarded as the variance of physical parameters in highly perturbed media
- right: comparison between results by WBM and 4th-order FDM, and analytic solutions.

The WBM generates accurate results while the FDM displays artificially attenuated results.

3.2 Stability test

- left: pointwise random heterogeneous medium with a standard deviation of velocity perturbations (σ = 25%: max. perturbation: 98%)
- right: Van Karran random heterogeneous medium with σ = 0.05 km/s, and σ = 0.2% (max. perturbation: 92%)

The WBM allows high stability even in extremely perturbed media.

3.3 Implication in measured scattering attenuation rates

- Minimum scattering angle (θ_m) measured by the wavelet-based study in media perturbed by 10% to 40%.

4 Modelling in a medium with a fluid-filled crack

- left: a model with a fluid-filled crack and an explosive source
- middle: wave propagation in a homogeneous medium
- right: wave propagation in a randomly perturbed medium

The WBM can deal localised zones of strong contrast in the scheme without introduction of additional boundary conditions.

5 Modelling in a fault zone (rupture propagation)

5.1 Model and snapshots

- Source: 90° dip-slip rupture with horizontal propagation
- Fault zone (Ωz): randomly perturbed (10% for Ωz, Ωz = 3 km for Ωz-low velocity medium
- Rupture distance: 0.8 km
- Rupture velocity: 0.4 km/s
- This time domain model
  - Permanent displacements (N) are found in a four-leaved pattern around the rupture plane, and considerable energy (I') is trapped and propagate along the fault plane.
  - Each fault segment can readily incorporate its own displacement time history.

The WBM can consider realistic distance sources with complex forms (i.e., unpredictable in time) of displacement time function in heterogeneous media in a direct way.

6 Modelling in subduction zones (SH waves)

6.1 Simplified slab models

The source lies

- case A: just below the upper boundary
- case B: just above the lower boundary
- background: stick-slip (Kennett et al., 1995)
- slab 3, 5° velocity anomaly, 0 = 40 km, γ = 30°

The WBM can be extended to topography problems [2] using a grid mapping technique.

6.2 Snapshots

- The relative source position plays an important role in waveform variation. Significant interface waves and critically reflected waves are observed, and they affect wave trains recorded in a free surface. In tectonic regions, hypocenters are naturally close to coherent tectonic structures and reflected waves are affected severely even by small contrast structures.

7 Conclusions

For realistic modelling in tectonic regions, when hypocenters are close to (or inside) tectonic structures, numerical techniques which can deal with dynamic source process and heterogeneities in source area accurately are needed. The wavelet-based method (WBM) provides a good representation for a wide range of such studies. The strong points of the WBM are:

- The WBM has high accuracy and stability, which allow accurate modelling in highly heterogeneous media, and in complex media with strong contrasts. The WBM provides correct time responses for quantitative seismic studies.
- The WBM can implement complex dynamic sources and can readily consider different displacement time history at each segment of rupture plane.
- These sources can be implemented directly in heterogeneous source region with no need of heterogeneity in source regions.

References