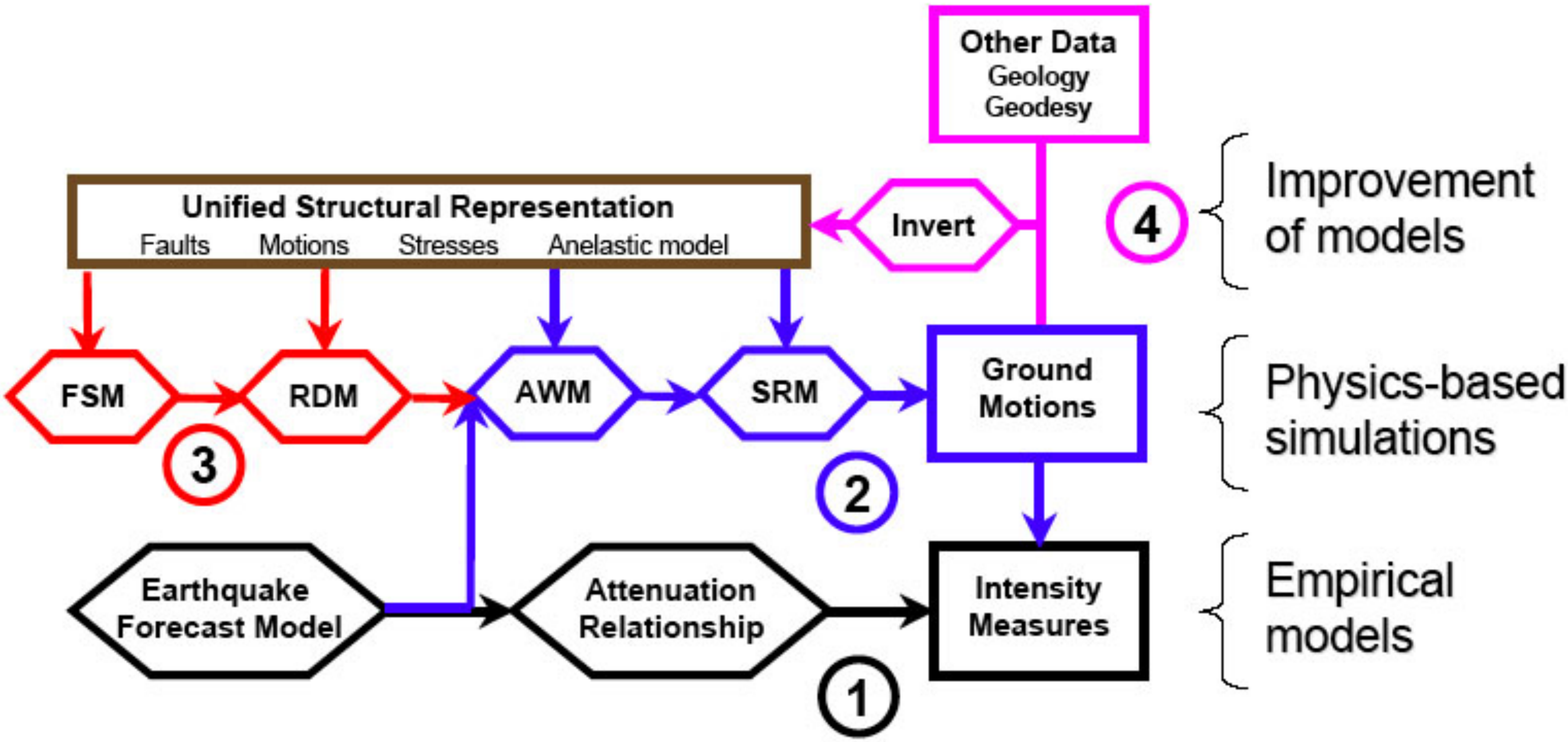
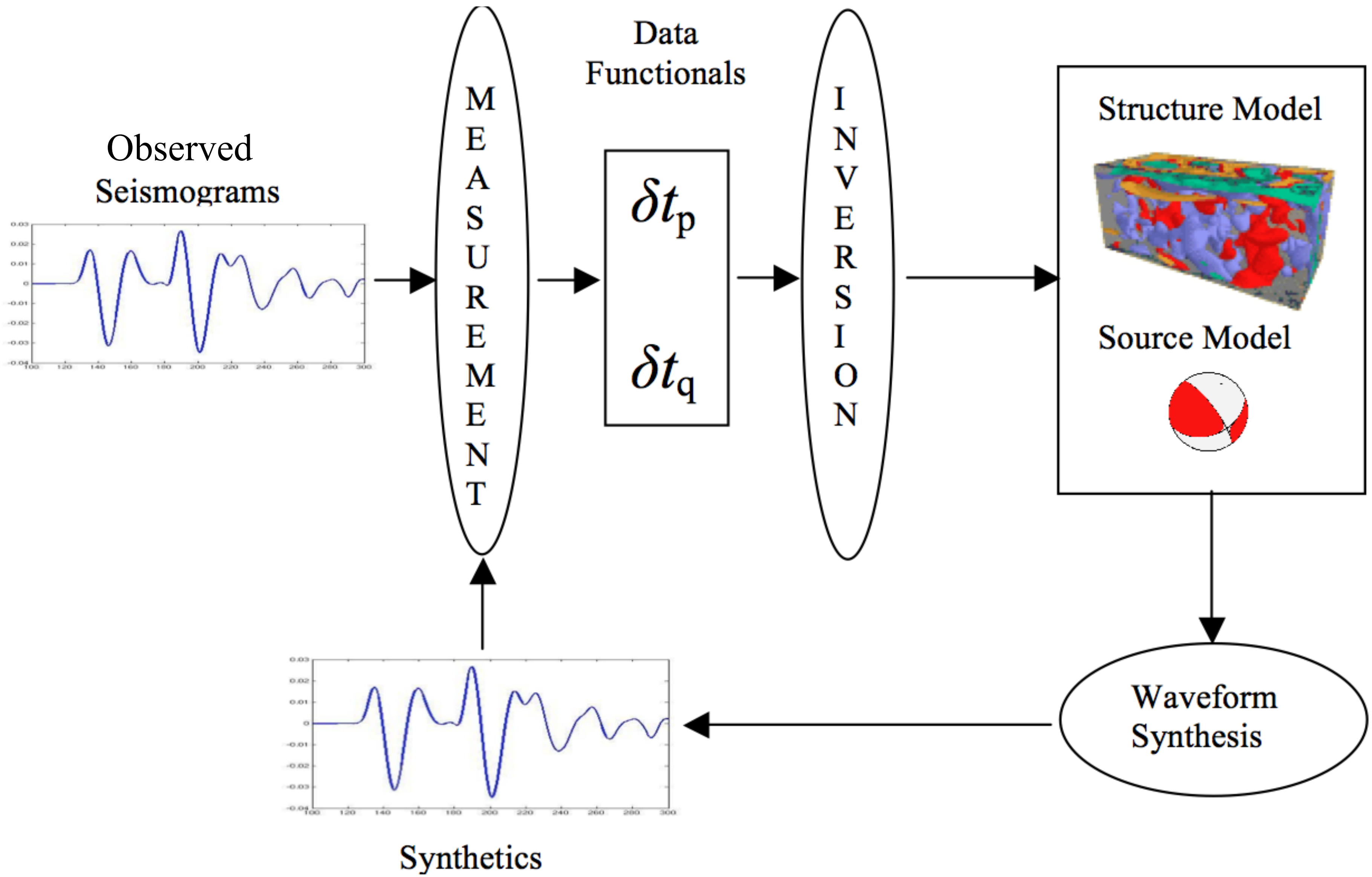
Tera3D

F3DT IS COMPUTATIONAL PATHWAY 4





Observed
Seismograms
M E A S U R E M E N T
Data
Functionals
δt_p
δt_q
I N V E R S I O N
Structure Model
Source Model
Waveform
Synthesis
Synthetics

Scattering-Integral (SI) Method

Data functional:

$$d_{in}^{sr} = D_n\left[u_i^s(\mathbf{x}_r, t),\ \tilde{u}_i^s(\mathbf{x}_r, t)\right]$$

Seismogram perturbation kernel:

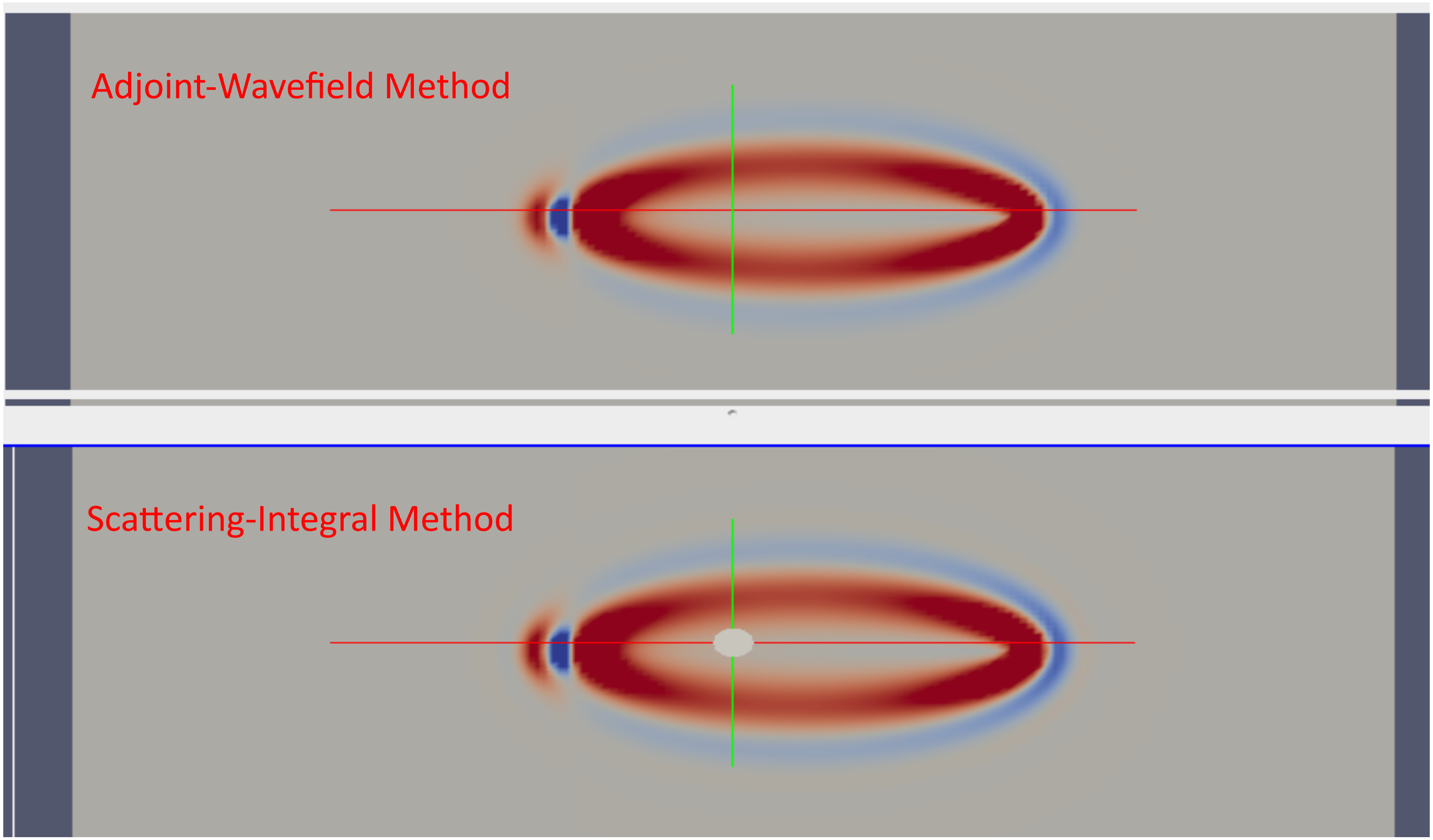
$$\delta d_{in}^{sr} = \int dt\, \boxed{J_{in}^{sr}(t)}\, \delta u_i^s(\mathbf{x}_r, t)$$

Fréchet kernel:

$$K_{d_{in}^{sr}}^{c_{jklm}}(\mathbf{x}) = -\int dt \int d\tau\, J_{in}^{sr}(t)\, \partial_k \boxed{G_{ji}(\mathbf{x}, t-\tau; \mathbf{x}_r)}\, \partial_l u_m^s(\mathbf{x}, \tau)$$

Receiver Green Tensor

Chen, Jordan & Zhao, GJI (2007)

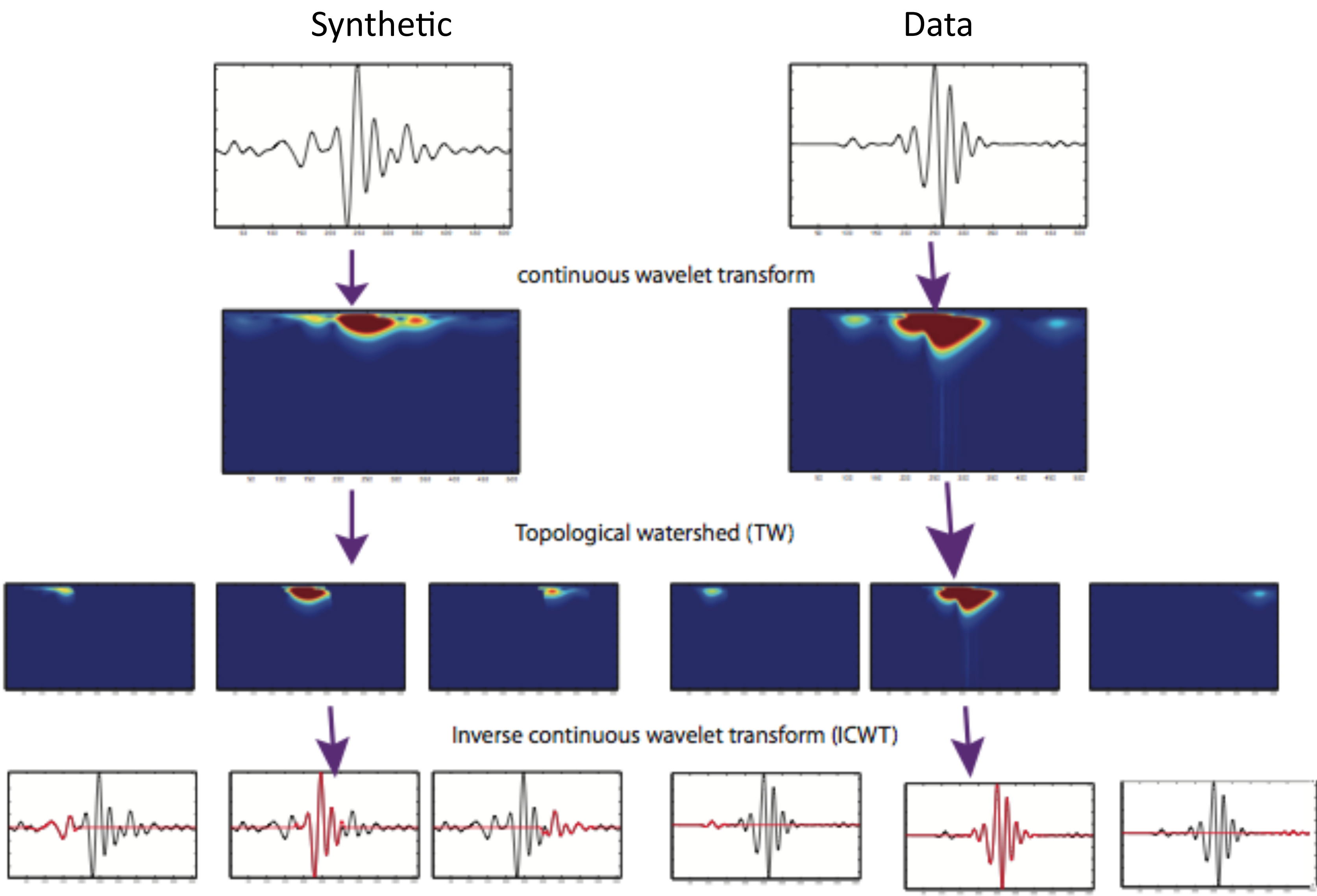


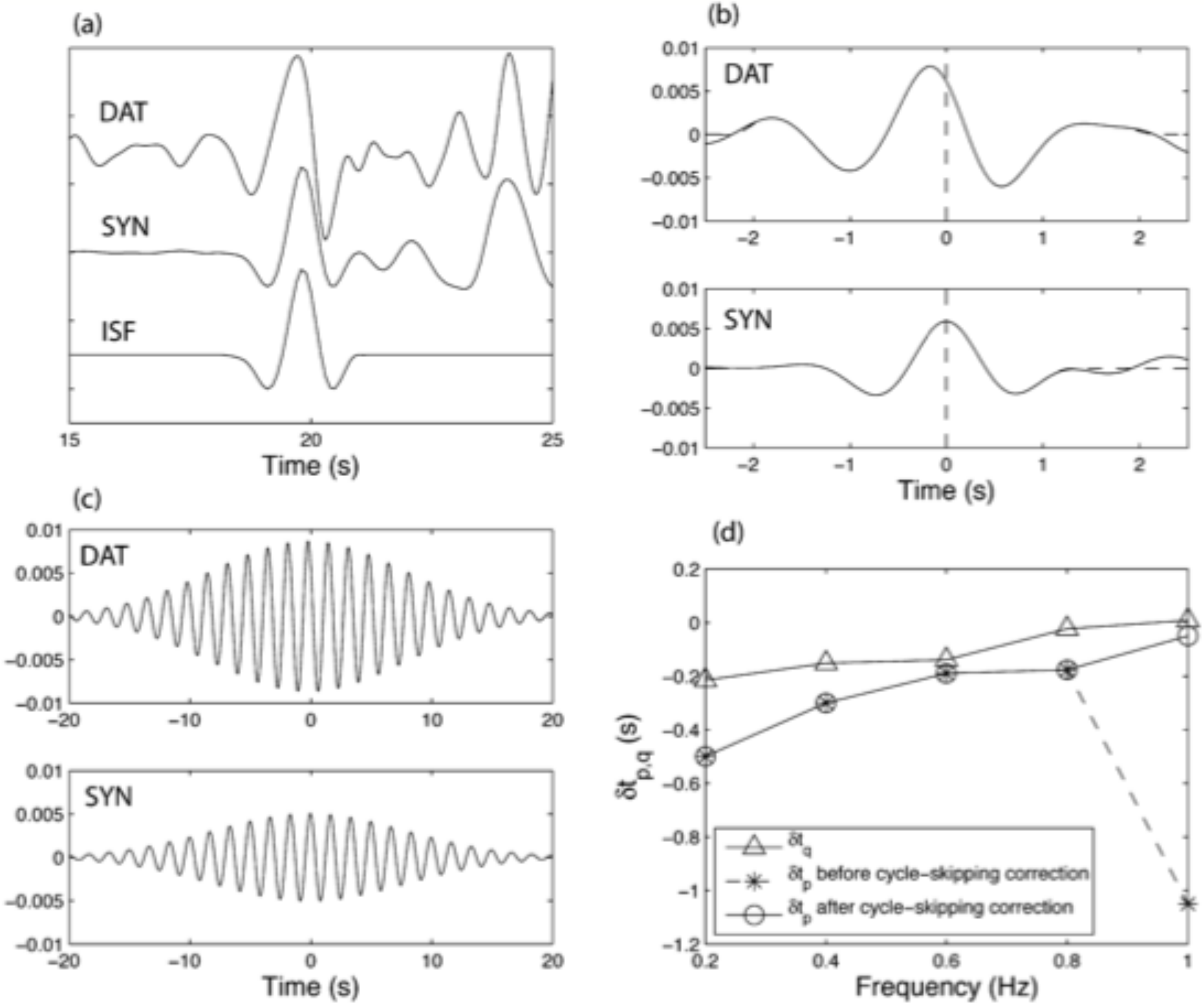
Zhang, Lee & Chen (2010)

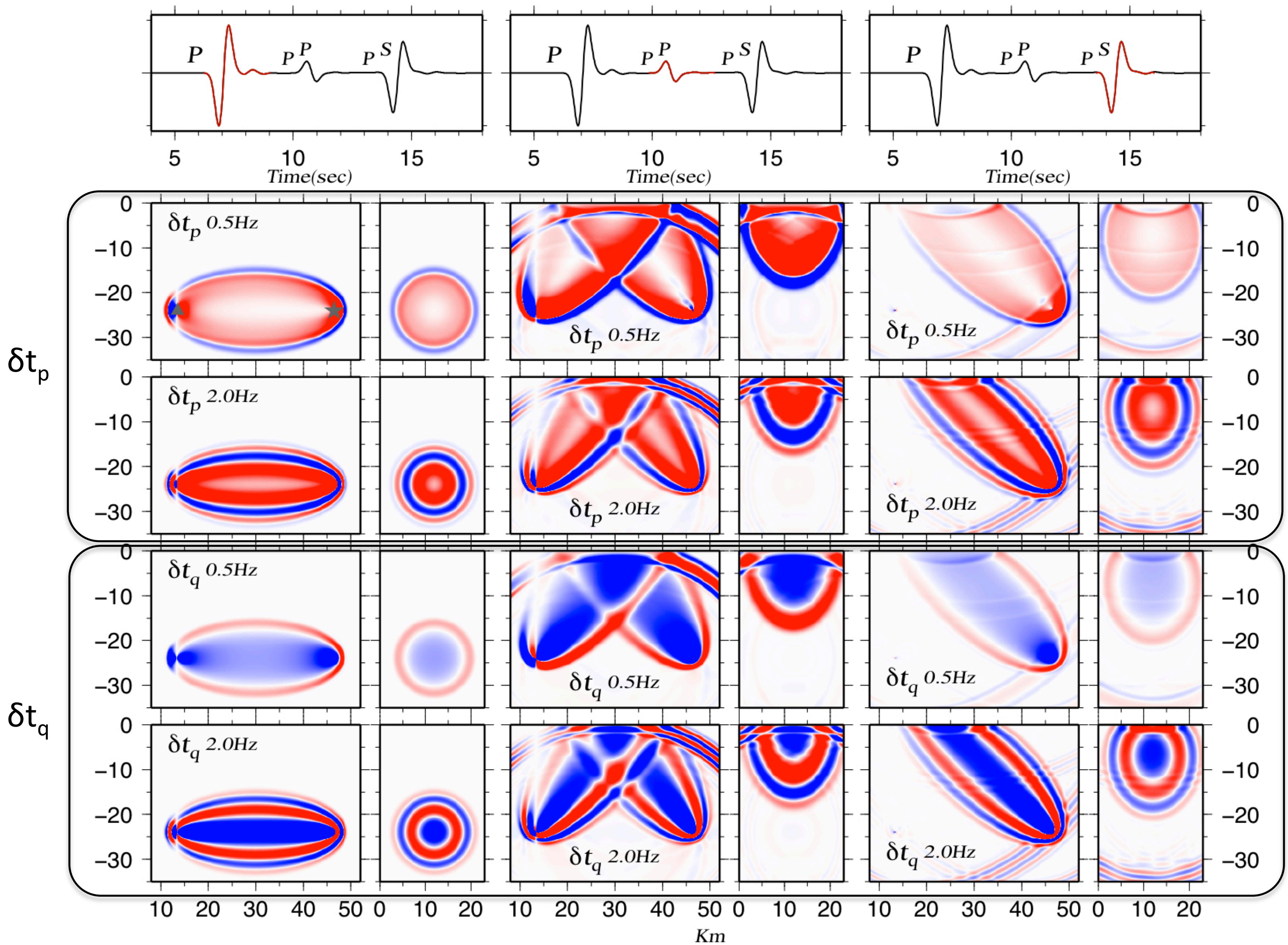
Computational Cost Comparison

Cost	SI method	AW–CG[a]
Storage requirement	$3N_rN_VN_T$	N_V
Number of simulations	$3N_r + N_s$	$6N_s$
Number of time integrations	$2N_t\ N_V\ N_u$	$2\ N_V\ N_s$
I/O cost	$N_uN_TN_V$	$2N_sN_V$
Requires solving a linear system?	Yes	No
Optimization algorithm	Gauss–Newton	Conjugate-Gradient
Number of iterations needed to match one Gauss–Newton step	1	6–7

Automated Waveform Selection Algorithm

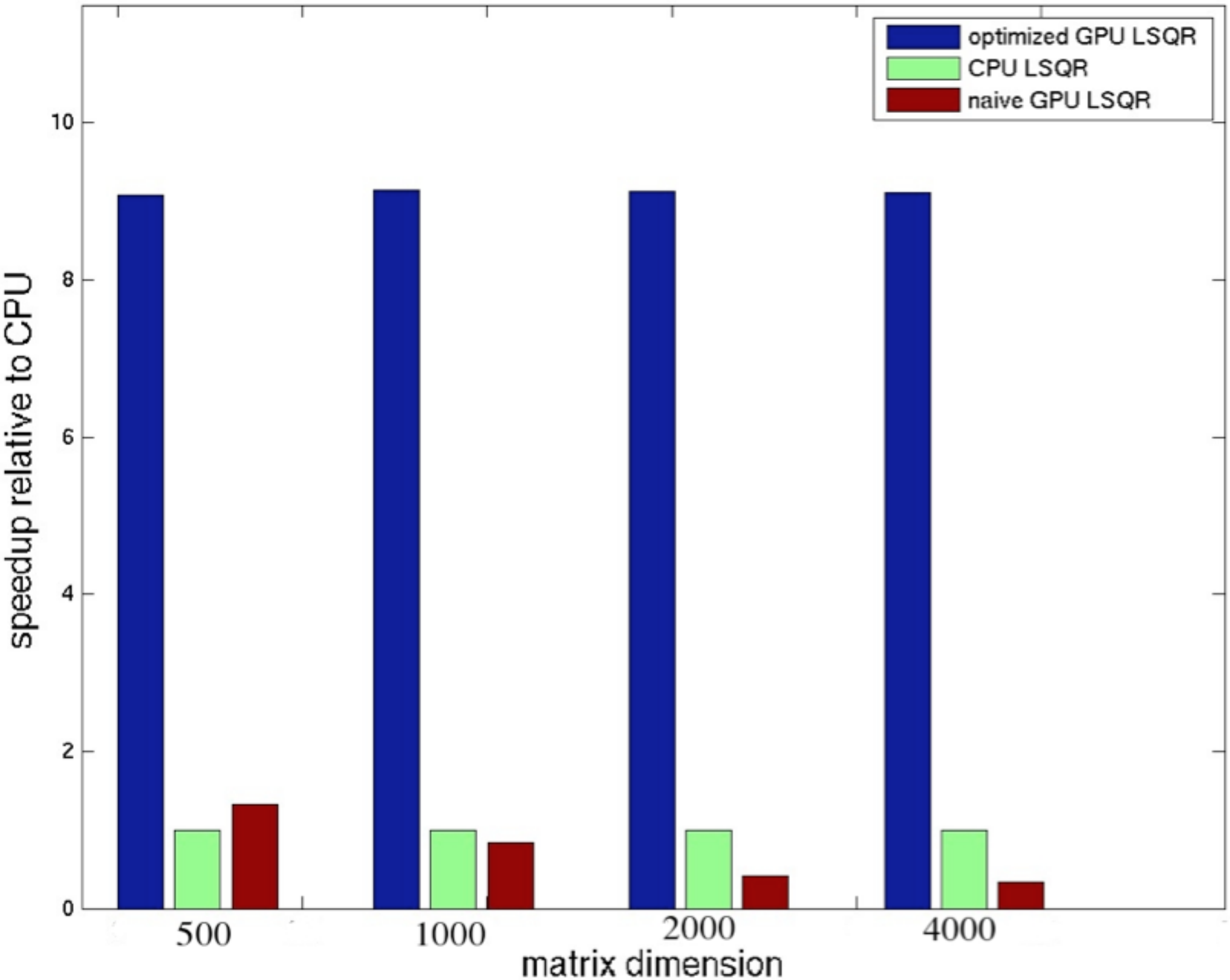



(a)
DAT
SYN
ISF
15
20
25
Time (s)
(b)
DAT
SYN
0.01
0.005
0
−0.005
−0.01
−2
−1
0
1
2
Time (s)
(c)
DAT
SYN
−20
−10
0
10
20
Time (s)
(d)
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
−1.2
$\delta t_{p,q}$ (s)
0.2
0.4
0.6
0.8
1
Frequency (Hz)
δt_q
δt_p before cycle−skipping correction
δt_p after cycle−skipping correction



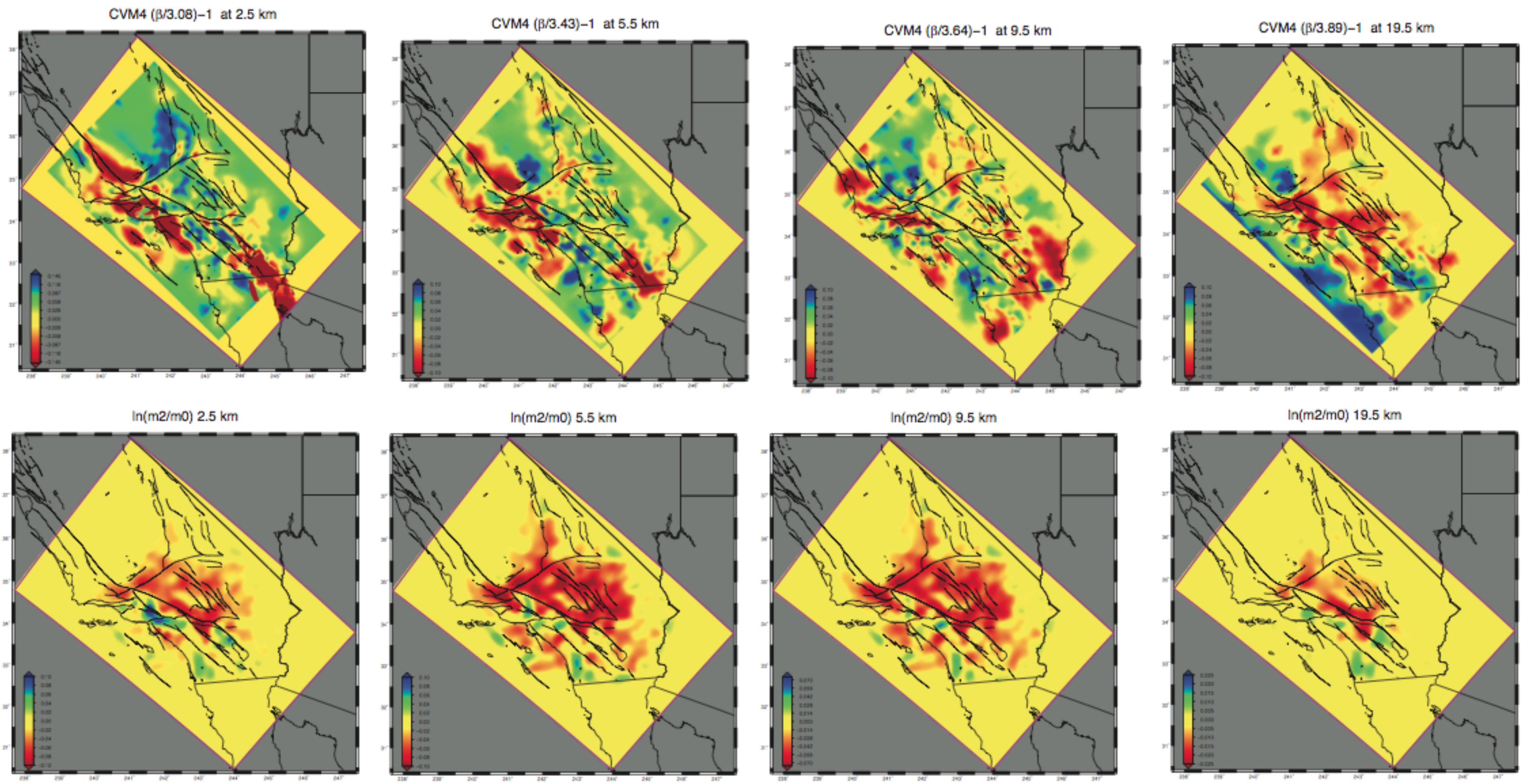
Chen, Jordan & Lee, GJI (2010)

PLSQR: A GPU-accelerated, MPI-Parallelized LSQR Code for F3DT

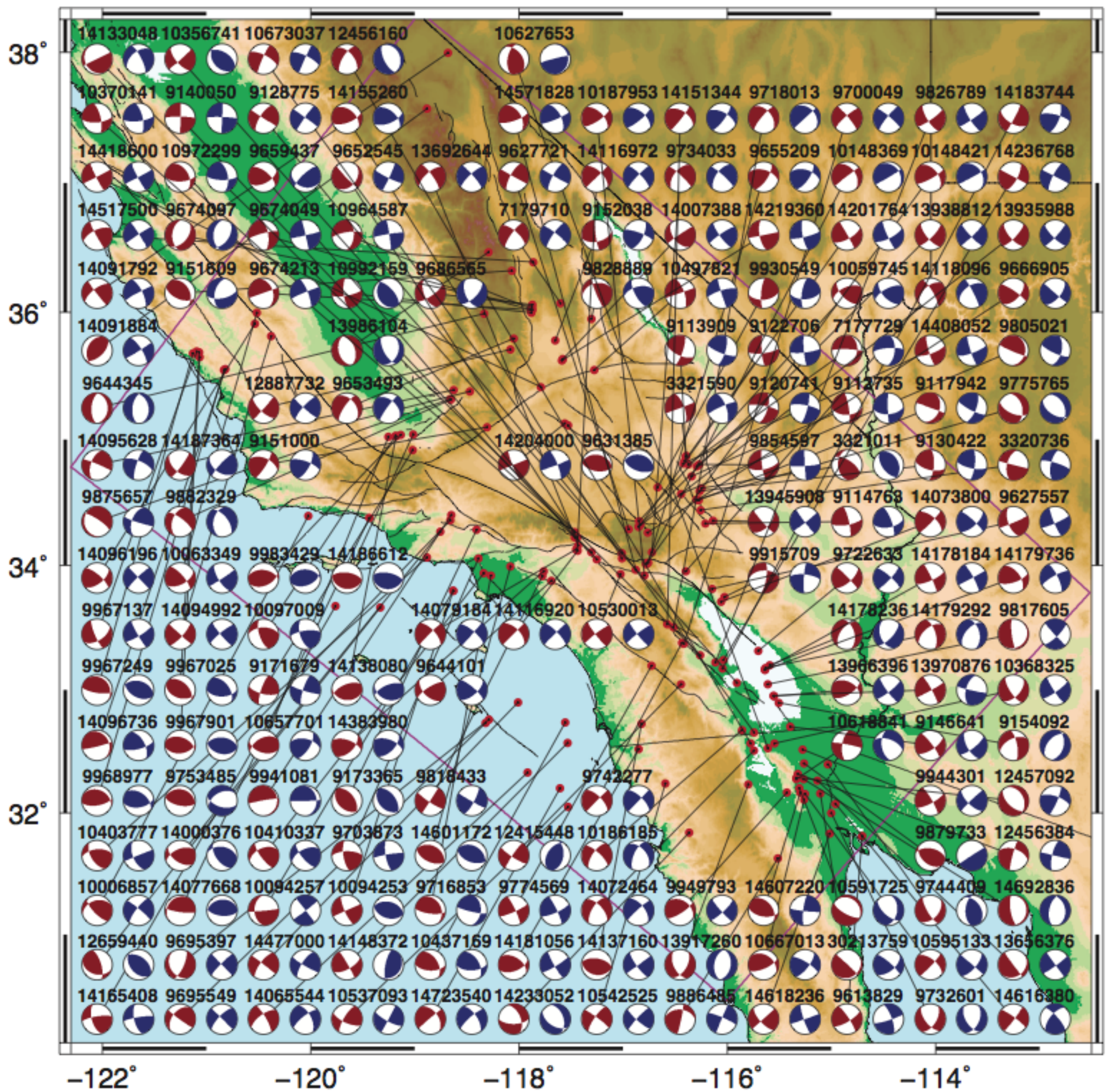


Huang et al. 2010

CVM4SI2


CVM4 (β/3.08)−1 at 2.5 km
CVM4 (β/3.43)−1 at 5.5 km
CVM4 (β/3.64)−1 at 9.5 km
CVM4 (β/3.89)−1 at 19.5 km
ln(m2/m0) 2.5 km
ln(m2/m0) 5.5 km
ln(m2/m0) 9.5 km
ln(m2/m0) 19.5 km

Rapid CMT Inversion in CVM4SI2



Summary

- A unified approach for F3DT and source inversion based on the SI method is successfully implemented for Southern California.
- GSDF measurements provide better linearization, allow for more intuitive model evaluation and faster convergence in F3DT.
- RGT provides capability for real-time source inversion in a 3D Earth structural model, physics-based hazard analysis and a unified framework for constructing partial derivatives and Fréchet kernels for seismic inversions.