Implemention of free-surface topography in Hercules

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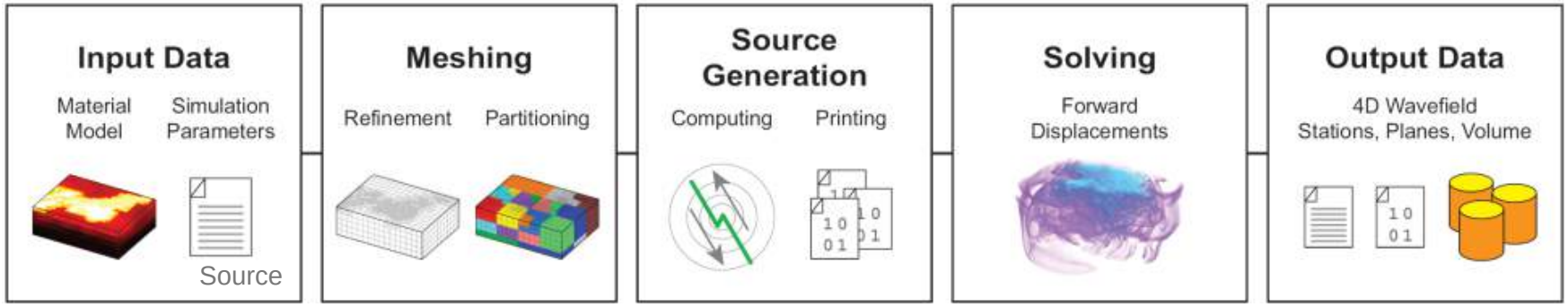
Hercules

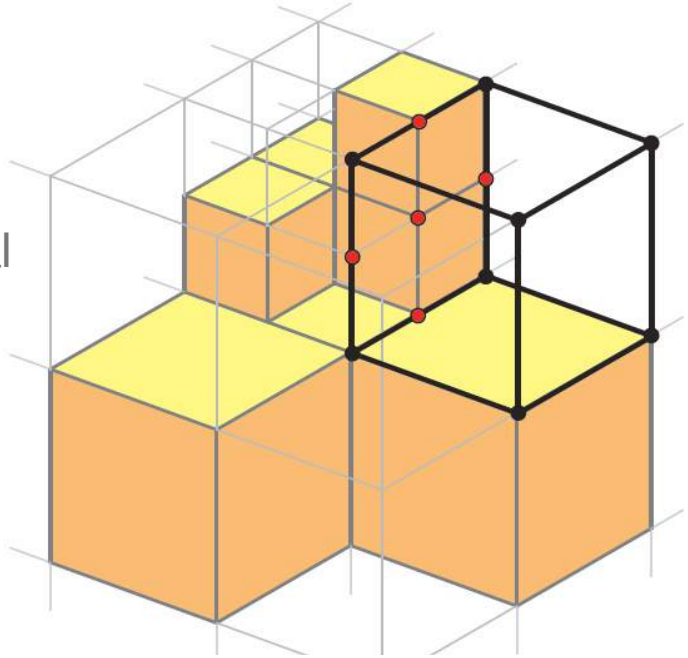
Our octree-based finite element tool for modeling earthquake ground motion* (Tu et al., SC2006)



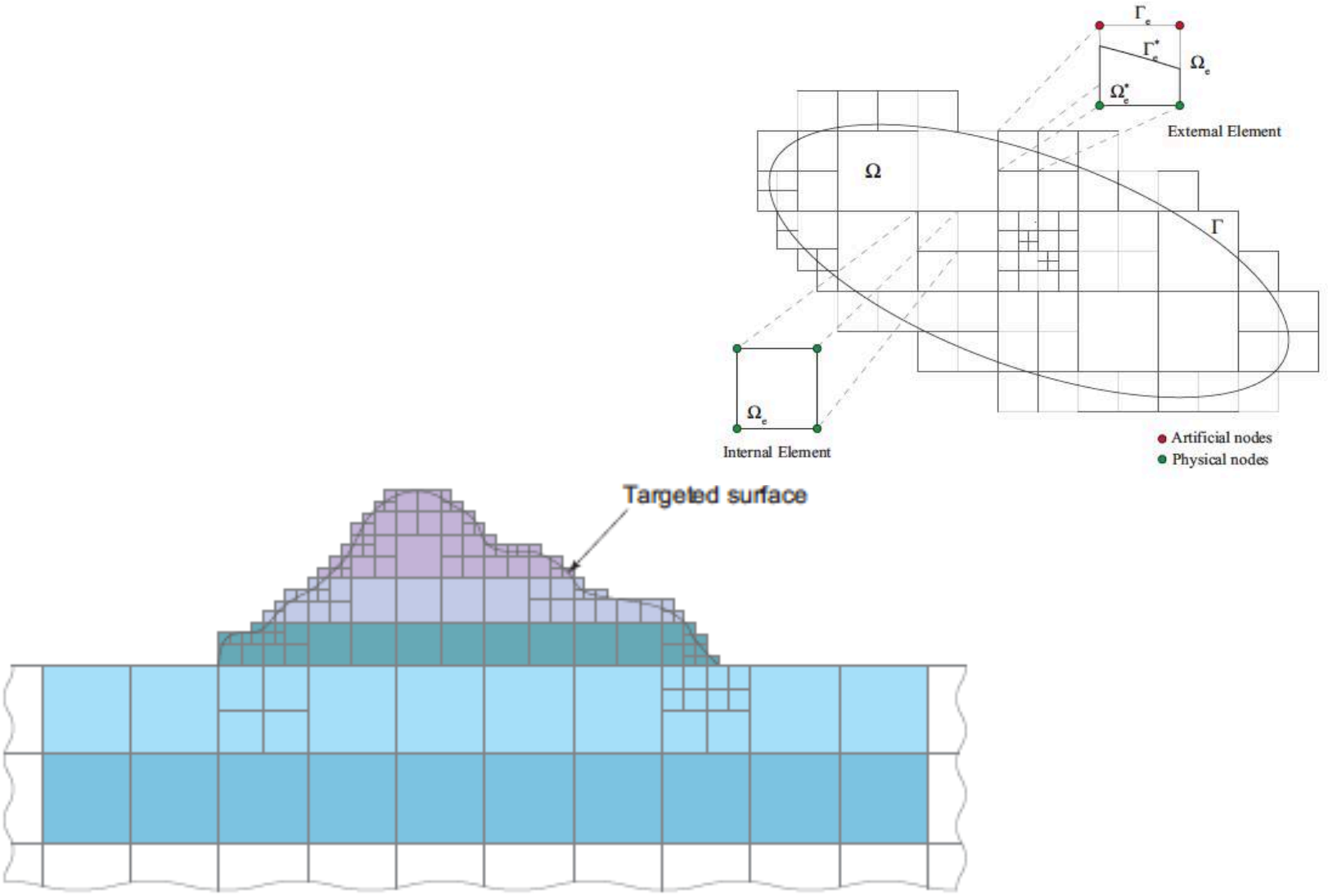
Octree-based FEM mesh

Mesh tailored to local shear wavelength

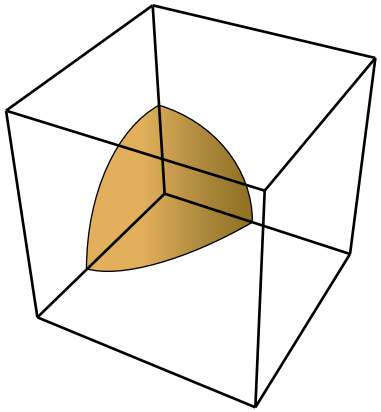
(trilinear; more recently triquadratic)

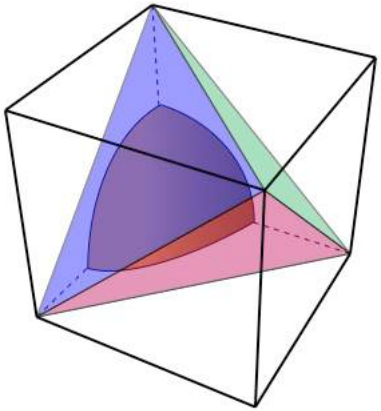


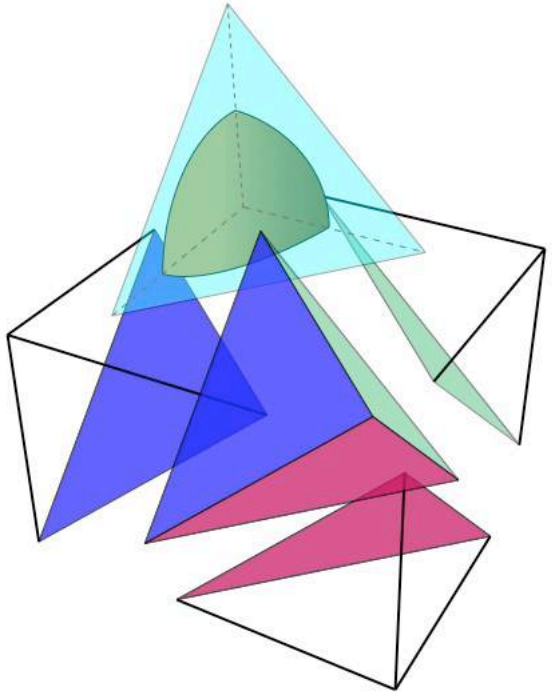
Surface Topography − Conceptual Model

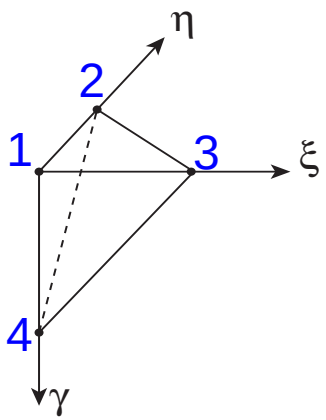


Virtual Topography





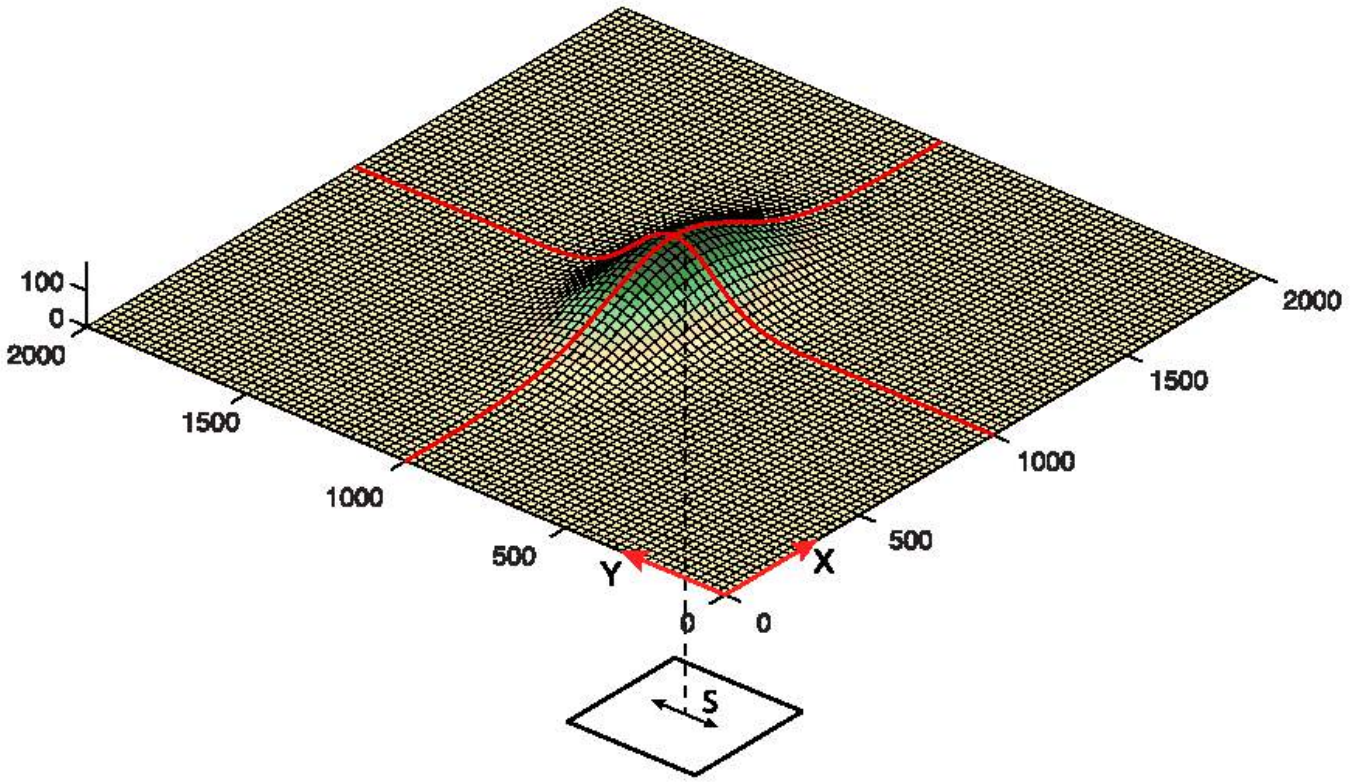




Cubic elements (octants) on the topographic boundary are divided into tetrahedra with local stiffness matrices that are computed only once, thus preserving Hercules' scalability.

Restrepo and Bielak, IJNME, 2014

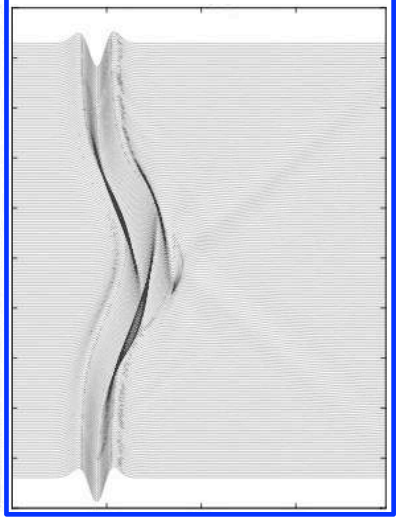
Model problem (elliptic Gaussian surface)

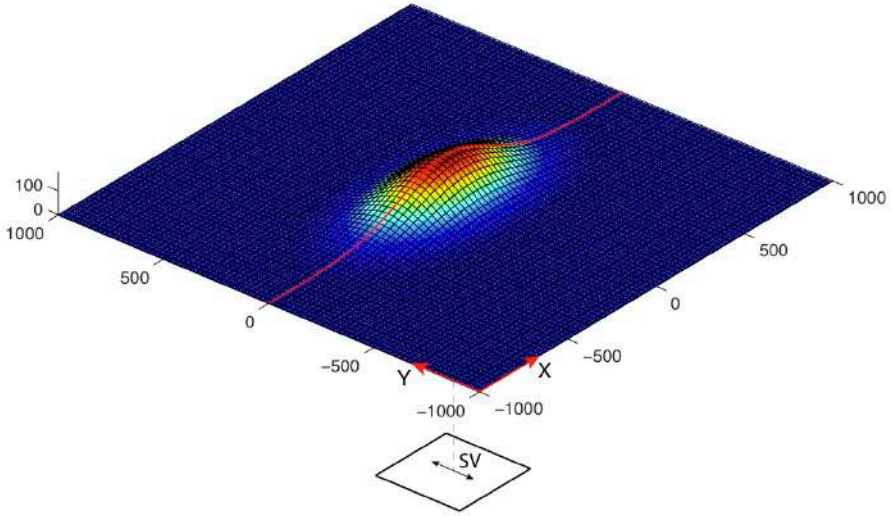


Verification

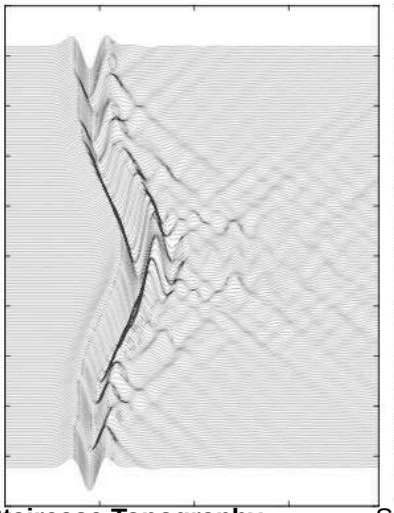
Spectral Elements
Komatitsch and Vilotte (1998)

Hercules Virtual Topography
Using effective 10 ppwl

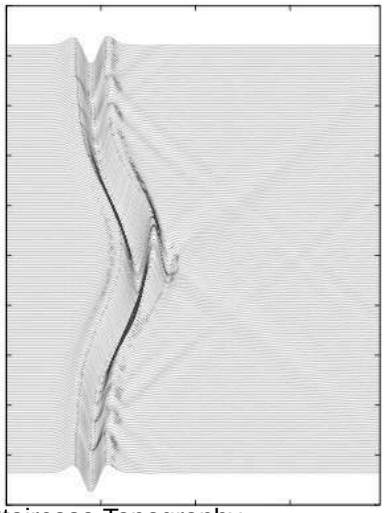




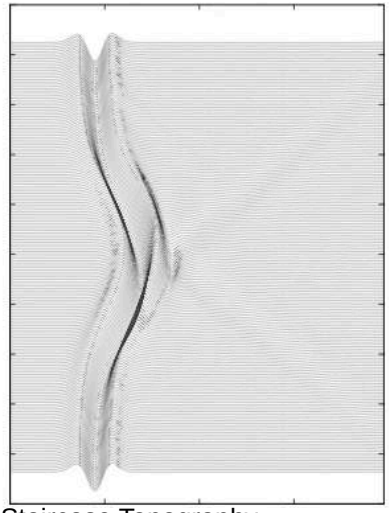
Elliptic Gaussian surface in a halfspace



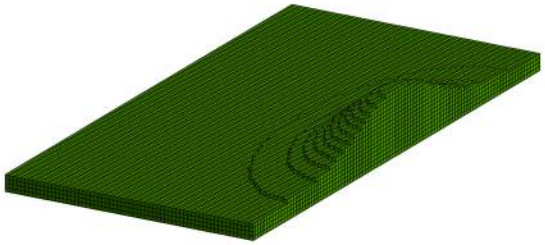
Staircase Topography
Using 10 ppwl



Staircase Topography
Using 20 ppwl



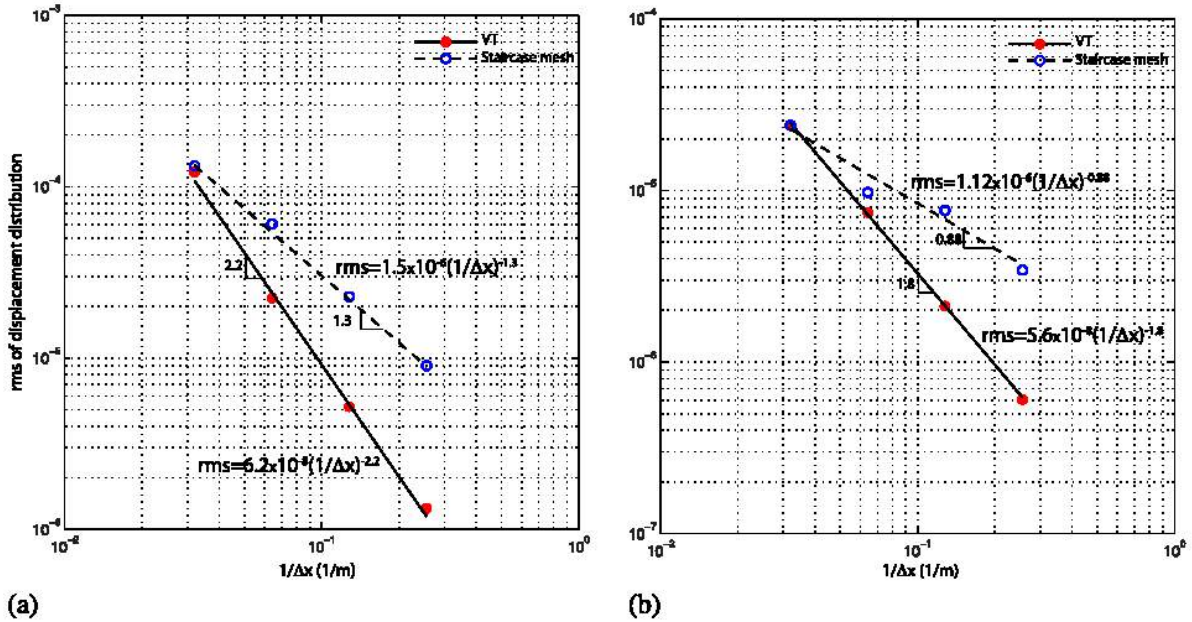
Staircase Topography
Using 40 ppwl



sample mesh
using 10 ppwl

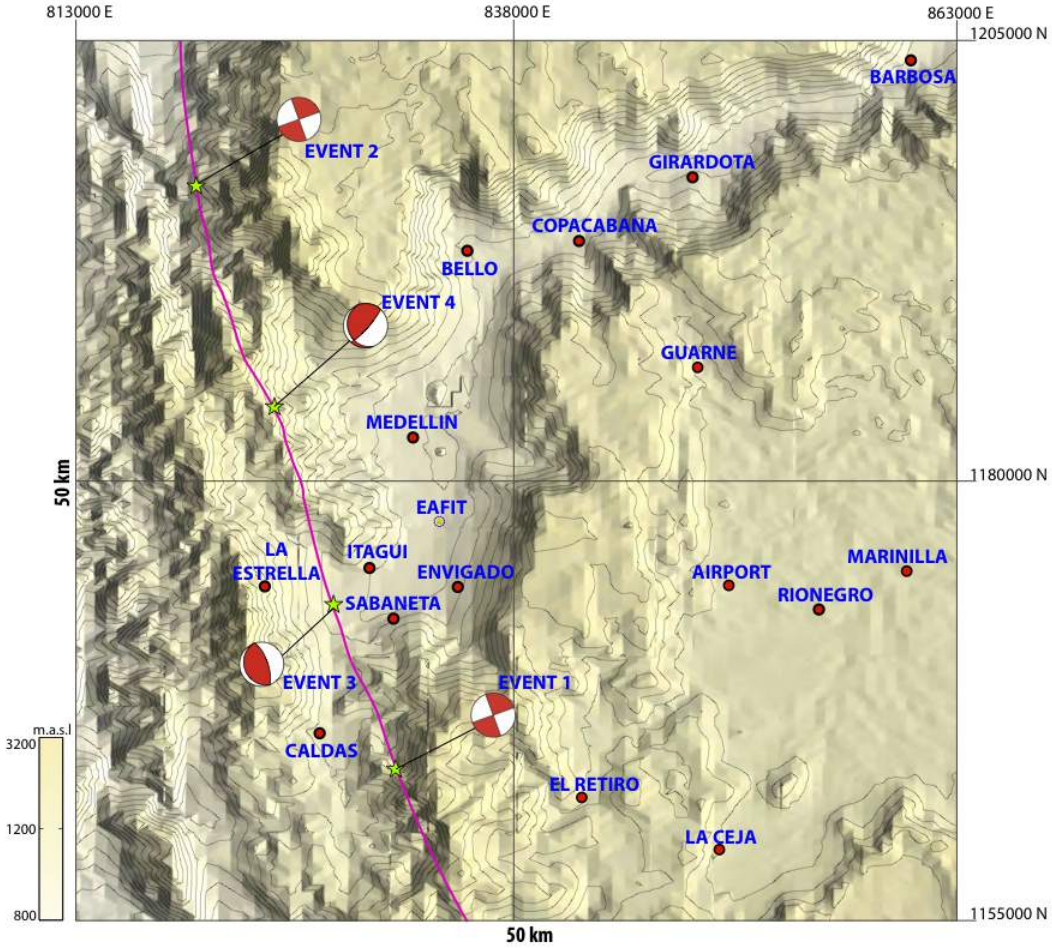
Convergence rate

Relative error norm



1/h

Valley of Aburra in Colombia (Medellin, 2nd largest city)

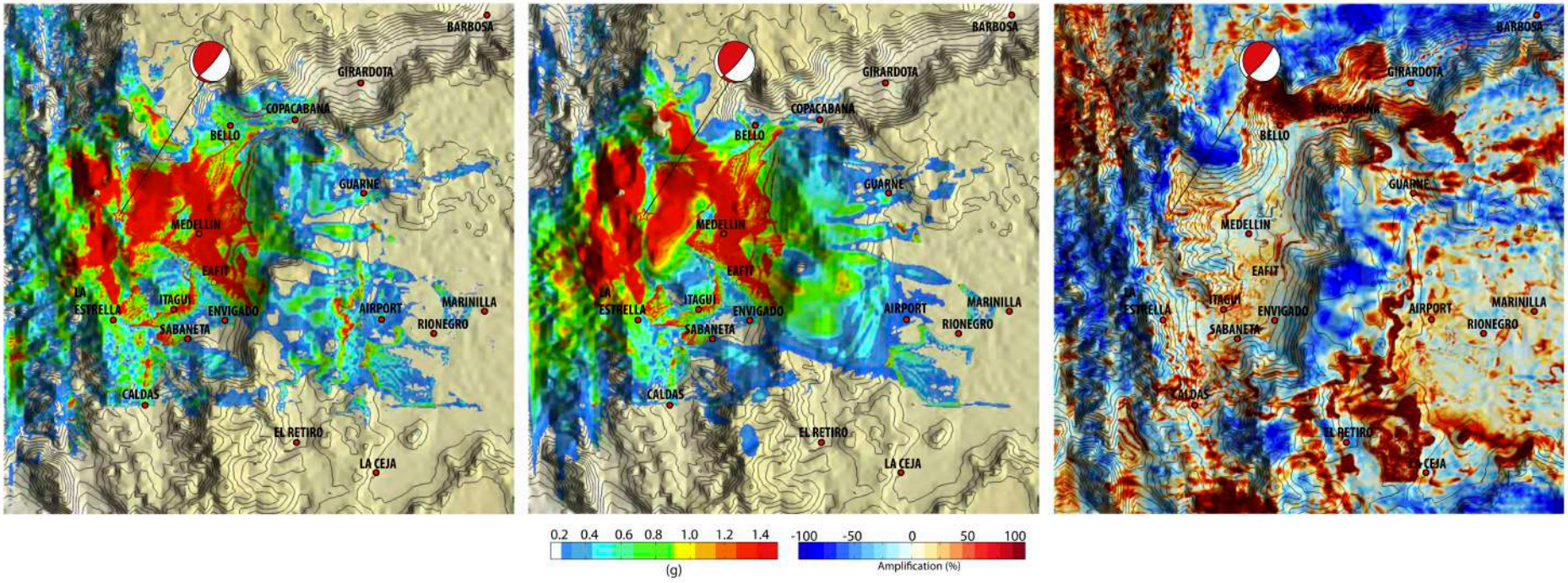


PGA with and without surface topography

With

Without

Normalized difference



Scenario earthquake with
5 Hz max. frequency