28*th* IUGG Conference on Mathematical Geophysics, June 7-11, 2010, Pisa, Italy
Session 4: Brittle deformation and computational seismology

A new approach to global seismic tomography that promotes sparsity with a new three-dimensional wavelet transform in spherical geometry

Ignace Loris[1], **Frederik J. Simons**[2], Sergey Voronin[2], Ingrid C. Daubechies[2], Guust Nolet[3], Stephen J. Judd[2], Massimo Fornasier[4], Phillip A. Vetter[2]

[1] *Vrije Universiteit Brussel, Brussel, Belgium*
[2] *Princeton University, Princeton, NJ, USA*
[3] *Université de Nice, Sophia-Antipolis, Nice, France*
[4] *RICAM, Linz, Austria*

Keywords: *seismic tomography; inverse theory; sparsity; optimization; algorithms*

Seismic wavespeed models of the Earth are routinely parameterized in terms of spherical harmonics, networks of tetrahedral nodes, rectangular voxels, or spherical splines. However, there as of yet few approaches to Earth model parameterization by wavelets, on the three-dimensional ball. Much is to be gained from procedures that do this efficiently, as (1) the multiresolution character of a wavelet basis allows for the models to be represented with an effective spatial resolution that varies as a function of position within the Earth. Furthermore, inversion schemes that are formulated in terms of wavelets can (2) exploit recent theoretical and numerical advances by which the most sparse solution vector, in wavelet space, is found through iterative minimization of a combination of the L2 (to fit the data) and L1 norms (to promote sparsity in wavelet space). With the continuing increase in high-quality seismic data, our focus should also be on (3) numerical efficiency and the ability to use parallel computing in constructing the model. In this presentation we propose a new wavelet basis on the sphere that has these three goals in mind. To form the numerical grid we begin with a surface tesselation known as the cubed sphere, a construction popular in fluid dynamics and computational seismology, coupled with a semi-regular radial subdivison that honors the major seismic discontinuities between the core-mantle boundary and the surface. By this mapping we transform the entire volume of the mantle into six portions. In the new variables, these chunks correspond to rectangular boxes with Cartesian coordinates. Standard algorithms can then be used to perform the wavelet transformation (or any other transformation) in each of the six bounded volumes. We choose a 4-tap discrete wavelet transform in the angular variables and use the Haar transform in the radial direction, with preconditioning and special boundary filters. We highlight the benefits of this construction and apply it to analyze the information present in several published seismic compressional-wavespeed models of the mantle, paying special attention to the statistics of wavelet coefficients across scales, and focusing on the likely gains of future inversions of finite-frequency seismic data using our new wavelet approach.