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From global functions to regional wavelets – multi-scale tomography of the Pacific upper mantle

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We propose a two-step lateral model parameterization approach, by which both the accuracy in the forward computation and the flexibility in the inversion stage are achieved. In the first step, the desired model is parameterized in terms of spherical harmonics. Spherical harmonics can be simplified to cosine and sine functions in the great circle path, allowing an efficient and accurate analytical solution for the path integral and therefore forward synthetics. Here, the normal-mode-based asymptotic coupling theory [Li and Romanowicz, 1995] is used for the computation of synthetic waveforms and partial derivatives. In the second step, partial derivative matrices w.r.t. spherical harmonics are mapped onto nodes of the spherical triangle meshes within the selected region. Taking advantage of the orthogonal property of spherical harmonics, the above conversion is straightforward. After the mapping, only about 10-15% of nodes receive effective sensitivities. As a result, the computation cost in the stage of inversion is significantly reduced. With the new matrices, we may utilize either the grid-based fixed-scale or the wavelet-based multi-scale inversion technique [Chiao and Liang, 2003] for the regional tomography. The new approach allows us to obtain partial derivative matrices from three different model bases for the same data set, and only one forward computation is required. We present the results for the Pacific upper mantle, compare models derived from different model parameterizations, and discuss how the effects of model parameterization are mapped into the tomographic features.