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TELESEISMIC TOMOGRAPHY: EQUATION (1) IS WRONG

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Teleseismic tomography, developed by Aki, Christofferson & Husebye in 1976, has been used to study the three-dimensional structure of the crust and upper mantle in hundreds of places world-wide. The “ACH” method and its variants use the times of teleseismic body waves arriving at a seismometer array from various directions to infer the three-dimensional distribution of wave speed beneath the array. These methods assume that structure outside the study volume is known (and almost always that it is simple), and are subject to biases caused by these unrealistic assumptions. The effects of structure outside the study volume are of the same mathematical order as the local-structure effects being sought, and computations using three-dimensional whole-mantle models show that they are of similar magnitude (Masson & Trampert, 1997).

These biasing effects may be responsible for various manifest inconsistencies in results from decades of ACH studies, such as:

- Gross discrepancies between models of the upper mantle derived from the EarthScope USArray deployment;
- Lack of agreement about the presence or absence of large magma chambers beneath resurgent calderas such as Long Valley and Yellowstone;
- Disagreement about the existence or nature of convective plumes in the upper mantle beneath Iceland, Yellowstone, the Eifel volcanic field, etc.

These biases can be eliminated by generalizing inversion methods to solve for the directions of the incident waves, analogously to solving for source locations in local-earthquake tomography. For planar wavefronts, each source adds three free parameters and the forward problem is particularly simple: The first-order change in arrival time at any point caused by perturbing the incident-wave direction equals the change in the time at the *un-perturbed* entry point into the study volume.

This fact enables the use of combined data from local and distant events in studying local structure, significantly improving resolution of structure, particularly in places such as volcanic and geothermal areas where seismicity is confined to shallow depths.

Most teleseismic tomography models in the literature probably contain significant artifacts and need to be re-evaluated.

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