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The computation of Finite-Frequency kernels without the paraxial approximation.

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The computation of finite frequency kernels using dynamic ray tracing, as originally proposed by Dahlen et al. (GJI, 2000) is very efficient, but the method has several disadvantages: it is prone to ambiguities and errors whenever the radius of curvature of a ray is smaller than the effective width of a kernel, and it breaks down completely for rays, such as PP or PKP that may reach as far as the antipode.

Motivated by the development of a wavelet parameterization in a ‘cubed sphere’, we have developed a new method for the fast computation of travel times and geometrical spreading factors. First, we confined our calculations to a finite set of discrete radii.

The goal then is to find the travel time and spreading factors for an arbitrary location along one of these radii. We use a traditional method to compute a fine fan of rays through a spherically symmetric model. For each ray we obtain the travel time and its second derivative with respect to distance from the ray in the ray plane, and the geometrical spreading at a series of nodes, typically spaced 15 km apart. These values are then interpolated to obtain data along each of the radii, resulting in a finite set (for each radius) of closely sampled data. Different arrivals are recognized by non-monotonic behaviour of the time as function of distance.

Travel times and geometrical spreading at arbitrary locations can be computed in two ways from this grid: either one interpolates from the times and spreading stored on the grid points, or one extrapolates a small distance from the nearest ray using dynamic ray tracing. We compare the two methods for efficiency and accuracy.