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Seismological Modeling of Traveltime Curves with Global Velocity Field Parameterized by Trigonometric Series

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The proposed seismological modeling aims to compare (identifying and correlating) the main traveltimes curves (obtained after a ray tracing considering acoustic and shear waves in the Earth interior) with those already known from the work of Jeffreys and Bullen (1940). Based on the values of the Earth center distance and corresponding seismic velocities extracted from the Preliminary Reference Earth Model (PREM), is made an adjustment of trigonometric series to such values using the least square method. Thus, considering the interior of the planet as an elastic, heterogeneous and isotropic media, it is possible to implement a computer algorithm that generates seismic two-dimensional velocity fields (in fact they can be seen as one-dimensional, because velocity is considered a function of just one variable: the depth in a three-dimensional Earth with iso-velocities that are spherical surfaces for each radius) and to carry out on them a seismic ray-tracing using a discrete and iterative version of the ray equations. Consequently, it is possible to calculate, numerically, rays arrival times and corresponding angular distance between epicenter and arrival ray position. Gathering and analyzing all produced numerical values by the built code, it is possible to produce a graphical view of several seismological events considering the most accepted Earth internal structure, highlighting, among them, the propagation of: P and S waves in the mantle; PKP, SKS and PKS events in the mantle and external core; and PKIKP, and SKJKS in the whole Earth. In order to produce some of such events, it is necessary to consider converted waves, specifically in the interface between the mantle and the external core. The shape of the traced rays and, mostly, the obtained traveltime curves, confirm a high level of correlation between Jeffreys-Bullen model and the results reached in this work. In addition, ray fields are produced for the Earth interior considering both: compressional and shear waves, where, in each case, shadow regions are obtained and they are in agreement with those that appear (no ray arrival at the points of such regions) in the Jeffreys-Bullen traveltime curves. The Earth interior velocity field is satisfactorily represented by the use of trigonometric series parameterization and the most important structural aspects (geometrical and kinematical) of such field are codified (or compressed) by the coefficients of the mentioned series. It means that, in a possible inversion procedure, the parameters to be estimated are just such coefficients. A spectral analysis can show us the relevant coefficients in order to optimize the number of parameters to be calculated by inversion, contributing to a reduction in the computational cost of the Earth interior imaging. Such parameterization has a disadvantage due to the Gibbs effect near discontinuities presented by the velocity field. In such cases, it does not produce a good concordance between the modeled traveltime curves and those provided by Jeffreys-Bullen. However, such effect disappears if another kind of parameterization is used. As a suggestion for a more advanced work, we can propose: wavelet series.