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3D simulation of seismic wave propagation around a tunnel using the spectral element method

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We model seismic wave propagation in the environment of a tunnel for later application to reconnaissance. Elastic wave propagation can be simulated by different numerical techniques such as finite differences and pseudospectral methods. Their disadvantage is the lack of accuracy on free surfaces, numerical dispersion and inflexibility of the mesh. Here we use the software package SPECFEM3D_SESAME in an svn development version, which is based on the spectral element method (SEM) and can handle complex mesh geometries. A weak form of the elastic wave equation leads to a linear system of equations with a diagonal mass matrix, where the free surface boundary of the tunnel can be treated under realistic conditions and can be effectively implemented in parallel. We have designed a 3D external mesh including a tunnel and realistic features such as layers and holes to simulate elastic wave propagation in the zone around the tunnel. The source is acting at the tunnel surface so that we excite Rayleigh waves which propagate to the front face of the tunnel. A conversion takes place and a high amplitude S-wave is radiated in the direction of the tunnel axis. Reflections from perturbations in front of the tunnel can be measured by receivers implemented on the tunnel face. For a shallow tunnel the land surface has high influence on the wave propagation. By implementing additional receivers at this surface we intent to improve the prediction. It shows that the SEM is very capable to handle the complex geometry of the model and especially incorporates the free surfaces of the model.