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Importance of a 3D forward modeling tool for surface wave analysis methods

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Since a few years, seismic surface waves analysis methods (SWM) have been widely developed and tested in the context of subsurface characterization and have demonstrated their effectiveness for sounding and monitoring purposes, *e.g.*, high-resolution tomography of the principal geological units of California or real time monitoring of the Piton de la Fournaise volcano. Historically, these methods are mostly developed under the assumption of semi-infinite 1D layered medium without topography. The forward modeling is generally based on Thomson-Haskell matrix based modeling algorithm and the inversion is driven by Monte-Carlo sampling.

Given their efficiency, SWM have been transfered to several scale of which civil engineering structures in order to, *e.g.*, determine the so-called $Vs30$ parameter or assess other critical constructional parameters in pavement engineering. However, at this scale, many structures may often exhibit 3D surface variations which drastically limit the efficiency of SWM application. Indeed, even in the case of an homogeneous structure, 3D geometry can bias the dispersion diagram of Rayleigh waves up to obtain discontinuous phase velocity curves which drastically impact the 1D mean velocity model obtained from dispersion inversion.

Taking advantages of high-performance computing center accessibility and wave propagation modeling algorithm development, it is now possible to consider the use of a 3D elastic forward modeling algorithm instead of Thomson-Haskell method in the SWM inversion process. We use a parallelized 3D elastic modeling code based on the spectral element method which allows to obtain accurate synthetic data with very low numerical dispersion and a reasonable numerical cost.

In this study, we choose dike embankments as an illustrative example. We first show that their longitudinal geometry may have a significant effect on dispersion diagrams of Rayleigh waves. Then, we demonstrate the necessity of 3D elastic modeling as a forward problem for the inversion of dispersion curves.