Some theoretical aspects of normal mode theory in linear viscoelastic bodies

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Abstract

Since the 70s, the development of rheological models to study the Earth's response to surface and tidal loading has advanced considerably. These models, characterised by a spherical symmetry, have seen a very broad range of applications in various fields of geodynamics, such as glacial isostatic adjustment, post-seismic deformations and the tidal deformations of the Earth and terrestrial planets. The "Love numbers" for a given Earth model are traditionally computed by the "viscoelastic normal modes" (VNM) method, based on the Laplace transform of the equations governing the quasi static deformations of a SNREI Earth model. Despite the success of the VNM technique, it is now well documented that it presents some weak points. For example, for finely-layered models or for layers with extremely low values of viscosity and/or a generalised Maxwell rheology, the computation of the Love numbers may be practically difficult. This arises from the numerical stiffness that is inherent in the multi-exponential nature of the VNM solution. Here, a new method is described, taking advantage of a long forgotten time-domain exact formula for the inversion of the Laplace transform, the so-called "Post-Widder (PW) formula", first obtained in the 30s. The pro and cons of the PW formula are discussed, and a few examples are given for case studies in which the traditional VNM method encounters difficulties. By a suite of examples, it is shown that the PW formula can be successfully applied to models with complex generalised transient rheology and it is very efficient for the computation of very short wavelength deformations, induced by fluctuations of small scale components of the cryosphere.

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